# MASCELLI'S CINE WORKBOOK

by

Joseph V. Mascelli, A.S.C.

BIRNS & SAWYER AUSTRALIA
JOHN BARRY
INCORPORATING
BIRNS & SAWYER (AUST.) PTY. LTD.
SALES — RENTAL — SERVICE
105 RESERVE RD., ARTARMON, N.S.W.
TEL.: 439 6955

## TEXT

## INTERNATIONAL EDITION

CINE/GRAFIC PUBLICATIONS·HOLLYWOOD

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## CINE EXPOSURE

Cine color film exposure is dependent upon TECHNICAL factors: *exposure time, lens aperture* and *film speed;* and upon SUBJECT factors: the *reflectance ratio* of significant light and dark areas in the scene and the *lighting contrast ratio,* which together determine the *Luminance range,* or overall *scene contrast.*

### TECHNICAL FACTORS

EXPOSURE TIME. Photographic exposure is determined by the *intensity* of the light and the *time* it is allowed to act on the sensitive emulsion. The greater the light intensity, the shorter the exposure time required. Exposure time (expressed in fractions of a second) is governed by the number of pictures (frames) exposed each second (fr/sec) and the opening of the shutter (expressed in degrees of angular opening of a disk revolving in front of the film plane). The greater the number of frames and/or the smaller the shutter's angular opening, the shorter the exposure time and the greater the light intensity required to compensate.

Professional cinematographers think of exposure time in terms of *normal 24 fr/sec camera speed and 170° to 180° shutter opening* — which results in approximately 1/50th second exposure time. Since the vast majority of professional motion picture scenes are filmed at normal sound speed, 1/50th second exposure time may be considered a more or less fixed quantity. (*See:* CINE CAMERA SHUTTERS for technical data on filming at other than normal camera speed.)

LENS APERTURES. Photographic lenses are equipped with an adjustable diaphragm that controls the size of the "hole" admitting light to the film. The various sized openings, made by adjusting the diaphragm leaves, are referred to as "stops" because they hold back or stop all but a precisely measured amount of light from passing through the lens. The lens diaphragm may be opened to a larger stop to admit more light, or closed to a smaller stop to reduce the light reaching the film.

Lens stops are calibrated in f-numbers and T-numbers. The f-number is the ratio of the focal length of the lens to its diameter.

$$\frac{\text{focal length of lens}}{\text{diameter of lens opening}} = \text{f/stop}$$

For example: A lens possessing a 50mm (2 inch) focal length and a 25mm (1 inch) diameter (opening) would be computed thus:

$$\frac{50}{25} = 2 \text{ or f/2}$$

The higher the number, the smaller the fraction, the smaller the lens opening.

The formula works equally well with ultra-speed lenses whose diameter may be *greater* than the focal length. A theoretical lens with a 25mm focal length and a maximum opening of 50mm would be computed thus:

$$\frac{25}{50} = .5 \text{ or f/.5}$$

Each full stop increases in the ratio of $\sqrt{2}$, or approximately 1.4, with slight rounding off for practical purposes. Each full stop in the series theoretically transmits *twice* the light of the next *higher* number and *one-half* the light of the *preceding* number. For example, f/2 is twice as fast as f/2.8, but only one-half as fast as f/1.4. Cine lenses are calibrated in full stops, except for the maximum aperture which may be less than a full stop because of optical or physical limits inherent in lens design and manufacture.

Note that f/stops are calculated purely on a *geometrical* basis by dividing the effective optical diameter into the focal length of the lens. The size of the "hole" or f/stop diameter is a measure of the light that *enters* the lens. Exposures made with *different* lenses at the same f/stop may vary greatly because of the variation in the number of component elements of the different lenses and variations in light losses due to reflection and absorption within the lens. A simple lens will transmit more light to the film than a complex lens, such as a zoom or retrofocus wide-angle lens. Therefore, it became necessary to devise a new method of calibrating cine lenses based on the light that *emerges* from the *rear of the lens* and actually forms the image.

All professional cine lenses are *photometrically* calibrated in "T" numbers which define the relative aperture of a lens adjusted to take proper account of the lens *transmittance,* so that the illuminance in the center of the lens field will be the same for all lenses at the same T-stop setting. The T-number may be considered the *transmission* number or *true f/stop* because it defines the *effective aperture* of a lens completely free from all reflection and absorption losses. T-stops employ the same series of numbers as f/stops but the T-number represents the f/stop number of an open circular hole or of a perfect lens having 100% axial transmission.

Similar T-numbers transmit the same light intensity to the film regardless of lens focal length or construction. T-stops are always *less* than f/stops because they account for light losses within the lens. There is no fixed ratio between T-stops and f/stops that would apply to all lenses. T-stop calibration marks

on the diaphragm ring signify the *actual* ratio of light transmission of the lens.

T-stops should always be used for exposure; f/stops should always be used for all calculations involving *object-image* relationships, such as depth-of-field, hyperfocal distance, extreme close-up photography, etc. Such optical calculations are based on the size of the hole or bundle of light rays which the lens admits to form the image. The Workbook refers to T-stops when dealing with exposure and f/stops when dealing with object-image relationships.

Lenses manufactured in accordance with American National Standards have their diaphragm openings calibrated so that they read correctly when they are moved from the widest aperture to the desired smaller aperture. This method of *closing* the diaphragm picks up any "backlash" or play that may be present in the movement of the leaves. Backlash is most prevalent in tiny diaphragms at very small openings. An extreme wide-angle lens diaphragm set at T-22 may be opened to T-16 — *and the leaves may not move at all!* The lens should be opened to its widest aperture and then closed to T-16. This is the most accurate method for adjusting *any* lens diaphragm. Make it a practice to always "stop down" a lens diaphragm to its proper aperture — open a lens diaphragm only for focusing.

Exposure Indexes (ASA and DIN) and exposure meters are calibrated in one-third stop increments so film speeds and lens apertures may be correlated. Professional cinematographers should compute exposure in terms of one-third of a stop, even though no such calibrations are found on cine lenses. Increases in exposure for Neutral Density filters, color filters and special effects filters, are generally given to the nearest one-third stop. Variations in camera frame rates and shutter openings may also be so calibrated. Film is manufactured and processed to within one-third stop accuracy. The LAB section of the Workbook will further explain how density timing of film is based on printing numbers that are divisibles or multiples of one-third.

Many cameramen think in one-half, one-quarter and even one-eighth of a stop, based on dividing a stop in half and then in half again and again. Although one-half stops are valid, because they are actually *three-sixths of a stop* (arrived at by dividing one-third stops in half); one-quarter and one-eighth stops are clumsy and do not readily correlate with exposure meters, film speeds or lab timing.

Learn to think in one-third, two-thirds and full stops for greatest accuracy and speed in computing exposure, particularly when deviations from normal 24 fr/sec are required. All frame rates, shutter openings, filters, film speeds, lab timing, will fall into

place all along the line. Become familiar with the series of T-numbers and use them correctly. An easy way to remember T-numbers is to note that numbers that are *two full stops apart,* regardless of their position in the series, are either *half* or *double* the value of the *opposing* number, with slight rounding off. Thus T-2 is twice T-4, but only one-half of T-1. Inbetween one-third stops also work in this manner: T-5 is twice T-10 but only one-half of T-2.5.

FILM SENSITIVITY. The speed of a cine camera film is expressed by an *Exposure Index* (E.I.) assigned by the film manufacturer. The E.I. is based on the film's sensitivity and latitude, its development, its intended use and the spectral quality of the light used for exposure. The number also includes a safety factor whenever the latitude of the film, or the requirements of the production process permits, in order to insure acceptable results under a variety of light conditions. E.I. numbers are determined on the basis of practical tests.

Contrary to common belief, ASA numbers do not apply specifically to cine materials. They are standard for still photography camera films only. (ASA are the initials for the old American Standards Association, now known as the American National Standards Institute, and now referred to as American National Standards.) However, ASA numbers (and British Standards Institute "BSI" numbers) are used interchangeably with E.I. numbers since they are numerically the same. The only other film speed ratings in popular use are the German DIN numbers, devised by the Deutsche Industrie Norm (German Standards Organization). A comparison of ASA and DIN numbers is displayed on the following page, together with lens aperture numbers to show how they relate in increments of one-third stop.

Doubling the ASA number doubles the film speed; halving the number halves the film speed. A film rated ASA 200 is twice as fast as a film rated ASA 100, but only half as fast as a film rated ASA 400. Doubling the film speed requires closing the lens one stop to compensate; halving the film speed requires opening the lens one stop. Each higher number in the ASA scale requires one-third stop less exposure. Each lower number requires one-third stop more exposure.

Similarly, each DIN number indicates a one-third stop difference in exposure. Three DIN numbers equal one stop. Adding three points to any DIN number doubles the film speed; subtracting three points halves the film speed. A film that is rated 21 DIN is twice as fast as one rated 18 DIN, but only half as fast as a film rated 24 DIN. The three points in the DIN scale correspond to an ND 0.3, which equals one stop. DIN numbers may also be

compared to the sound decibel — if a sound has *twice* the energy of another it is 3 decibels louder than the other. DIN numbers are actually easier to use than ASA numbers and provide a better indication of the relative speed of one film compared to another. DIN numbers may be subtracted from each other and the remainder divided by three to find the number of stops difference in film speed. Example, a film rated 10 DIN subtracted from 22 DIN is 12. Divide 12 by 3 and the difference is 4 stops.

E.I. numbers are *not* fixed values which cannot be changed if results of repeated tests indicate the need for such changes. They should be used as a guide only. Cinematographers should make exposure tests to establish their own film speed ratings for their particular method of working. This is particularly important when processing is switched to another lab, or when traveling about the world. Although color film processing has been standardized to a greater degree than black and white film, there still exists individual interpretation of the film manufacturer's instructions on color film development. Exposure tests should also be made whenever a particular mood, style or "look" is desired for story purposes. Or, whenever special diffusion, color filtering, or special exposure or color effects are required. A grainy, documentary, or newsreel appearance may be required for a flashback to a previous period; a hot, burned-up, overexposed appearance may be needed for adding pictorial credibility to desert scenes; or a dark, dismal, moody, underexposed effect may be required for a horror, murder, low key or atmospheric film. All of these special effects may require adjusting the film speed and/or the lab processing to achieve the desired screen image.

Tungsten light balanced (3200 K and 3400 K) color films always employ a lower E.I. when exposed in daylight with the Kodak Daylight Conversion filter No. 85 (or 85B), or its equivalent supplied by other film or filter manufacturers. The lower rating takes into account the 2/3 stop (Cine Factor 1.6) exposure increase required by the filter.

The manner of rating film sensitivity, or film speed, and the calibration of lens apertures, and their relationship to each other, must be thoroughly understood for properly computing cine exposure. Although it is a simple matter to adjust the exposure meter to the speed of the film and then simply read off the lens aperture and transfer the setting to the lens diaphragm, it is important that the professional cinematographer understand the many other factors that influence cine color film exposure.

## T-STOPS

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .50 | | | .7 | | | 1 | | | 1.4 | | | 2 | | | 2.8 | | | 4 | | | 5.6 | | | 8 | | | 11 | | | 16 | | | 22 |
| | .56 | | | .8 | | | 1.1 | | | 1.6 | | | 2.2 | | | 3.2 | | | 4.5 | | | 6.3 | | | 9 | | | 12.7 | | | 18 | | |
| | | .63 | | | .9 | | | 1.3 | | | 1.8 | | | 2.5 | | | 3.5 | | | 5 | | | 7 | | | 10 | | | 14 | | | 20 | |

## EXPOSURE INDEXES

### ASA

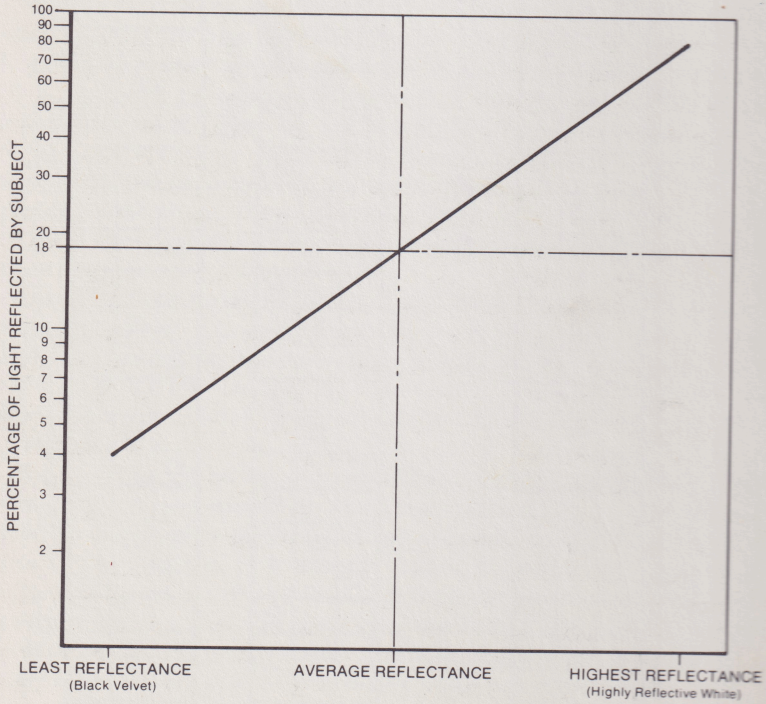
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | | 6 | | | 12 | | | 25 | | | 50 | | | 100 | | | 200 | | | 400 | | | 800 | | | 1600 | | | 3200 | | | 6400 |
| | 4 | | | 8 | | | 16 | | | 32 | | | 64 | | | 125 | | | 250 | | | 500 | | | 1000 | | | 2000 | | | 4000 | | |
| | | 5 | | | 10 | | | 20 | | | 40 | | | 80 | | | 160 | | | 320 | | | 640 | | | 1250 | | | 2500 | | | 5000 | |

### DIN

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | | | 9 | | | 12 | | | 15 | | | 18 | | | 21 | | | 24 | | | 27 | | | 30 | | | 33 | | | 36 | | | 39 |
| | 7 | | | 10 | | | 13 | | | 16 | | | 19 | | | 22 | | | 25 | | | 28 | | | 31 | | | 34 | | | 37 | | |
| | | 8 | | | 11 | | | 14 | | | 17 | | | 20 | | | 23 | | | 26 | | | 29 | | | 32 | | | 35 | | | 38 | |

## SUBJECT FACTORS

SUBJECT REFLECTANCE RATIO. The subject matter in the scene presents various surfaces that reflect different percentages of the incident light. These varying reflectances determine the *subject contrast*. Dismiss, for a moment, the color, quality, finish and shape of the various surfaces in the scene — and think in terms of uniform ambient light, so that only the *reflective intensity of the surfaces* may be considered. Think of each individual surface reflecting a particular gray tonal value to the camera that will fall somewhere on the photographic gray scale. The density, whether highlight or shadow, will photograph as a particular *degree of grayness* as determined by its reflectivity. *Reflectance* refers to the *percentage of incident light falling on a surface* that is *reflected* back to the camera. Reflectance of various surfaces varies from as low as 4% for very dark materials, such as black velvet, to as high as 81% for very light materials, such as a man's white shirt.




**This graph demonstrates why 18% is mid-point in the reflectance scale.**

The *average reflectance* (the mid-point in the photographic gray scale) for an average interior scene is 18%. This average figure is obtained by multiplying $4 \times 81 = 324$, the square root of which is 18. Rather than take various reflected light readings of different surfaces in the scene and averaging them, a photographic *gray card* with an 18% reflective surface may be substituted for the subject. Since incident light exposure meters are calibrated for this average 18% mid-point reflectance, the reflected meter reading off the gray card will be similar.

Average Caucasian flesh tones are recorded in this same mid-scale area on color film because they reflect approximately 20 to 25% of the incident light. However, there is no such thing as an average flesh tone considering the wide range of complexions on persons of various races. This figure, therefore, should be considered a guide for centering flesh tones on the H & D curve, realizing, of course, that lighter and darker faces will fall above and below this midway point. A reflected spot meter reading of a face may be used, instead of the incident light meter reading, if it is desirable to place a particularly light or dark flesh tone at mid-scale.

Average *exterior* reflectance is reduced to approximately 12%, because of atmospheric conditions which scatter the sun's specular light. The reflectance ratio, therefore, for an average exterior scene is less than for an interior. An outdoor reflected light meter gray card reading should be *increased approximately one-half stop* to compensate for this lowered average reflectance.

The color, character, and shape of a surface, and its position in relation to the camera and light source, also influence its reflectivity. Very light pastel colors, such as yellow, require less exposure than dark saturated colors, such as dark blue. Glossy and shiny surfaces reflect more light than matte or dull surfaces of the same color. A textured surface generally absorbs more light than a similar smooth surface, depending upon how deep its texture, and will, therefore, reflect less light. A curved surface may reflect more light than a flat surface, particularly if the flat surface is so positioned that the light is reflected away from the lens. A flat surface, however, positioned at the glare angle (so that it reflects directly into the lens) will possess greater reflectance than a curved surface. Specular sunlight and artificial spot-lighting will produce greater surface reflectance because the light's point source will be reflected in the surface. This effect is greatest with glossy or shiny surfaces. This is the reason that more brilliant color pictures are recorded under specular light conditions than under soft, diffused lighting which lacks a point source, such as an overcast sky or a photographic softlight employing indirect reflected bounce light.

LIGHTING CONTRAST RATIO. The *difference in intensity* between *key light* and *fill light* determines the *lighting contrast ratio,* which is generally referred to simply as the *lighting ratio.* The *key light* provides the *principal source* of illumination for the scene. The *fill light* provides illumination that *lightens* the *shadows* created by the key light. The key light is thus always more intense than the fill light. The *greater* the *difference in intensity* of key light to fill light, the *higher* the lighting contrast ratio. Lighting contrast is lowered as more fill light is employed because the intensity of fill light begins to approach that of the key light. Lighting contrast is increased as fill light is decreased. Maximum contrast is achieved with a specular key light when the fill light is eliminated. The resulting high ratio lighting produces little or no shadow detail because the key light provides the only illumination. The need and effectiveness of the fill light is also determined by the angle of the key light in relation to the camera and the subject. The closer the key light to the camera, the less the need for fill light because very little shadow is apparent. As the key light is moved away from the lens and around to the side of the subject the shadow created by the key light increases in area, so lighting contrast increases. Whether the scene is front, side or backlighted, therefore, also influences the lighting contrast ratio.

Outdoors the sun key lights the scene. Indoors a spotlight is generally employed as a key light, although any type of light may be used providing its intensity is greater than the other lights on the subject. The *fill light* provides illumination that *lightens the shadows* created by the key light. Outdoors the sky reflects sunlight into shadows created by the sun. The sun and sky thus act as key and fill on a sunny day. Indoors a softly diffused flood light is positioned on the opposite side of the key light, generally close to the camera, to provide fill light. Outdoors or indoors the fill light should provide illumination without creating surface or cast shadows. The audience should not be aware of the fill light's existence. An apparently nonexistent fill light betrays its presence when it produces shadows! Outdoors a single sun produces a single shadow. Natural exterior fill light is shadowless because it is softly diffused skylight arriving at the subject from a wide source. Contrived exterior fill light, provided by reflectors or artificial "booster" lights, should duplicate this natural light condition for an acceptable effect. Artificial fill light on interior scenes should provide similar softly diffused illumination without a discernable shadow. Positioning the fill light close to the lens so that its shadow falls directly behind the subject works well, particularly if the subject is pulled away from the background. It is also possible to position the fill light other than near the lens so that its shadow falls off-screen. This may, however, create facial

shadows if the fill light is angled to the player. Flat front softly diffused fill light is safest and easiest to use because it provides almost shadowless illumination.

In actual practice the lighting ratio is determined in the following manner: the *ratio* is the *intensity* of the *key light plus the fill light* to the *fill light alone*. It is important to compute the ratio in this way since the brightest area of the subject is where the rays of *both the key and the fill are superimposed*. For example, a key light angled at 45 degrees to the player and a fill light close to the camera would *both* illuminate the *center portion* of the player's face, if he were facing the camera and looking to the side of the lens. If the *key light* is *twice* as intense as the *fill light,* the area illuminated by *both lights* would receive *three units* of light (two from the key light and one from the fill light), while the area illuminated by the *fill light alone* would receive only *one unit*. The resulting lighting ratio would be 3 to 1. It is important to comprehend this method of computing the lighting ratio because even veteran cinematographers mistakenly speak of the intensity of the *key to fill* as the ratio. The above example would thus be *wrongly* defined as a 2 to 1 ratio. This wrong method often leads to the establishment of higher light levels than desired.

A typical lighting example will demonstrate what happens when the key to fill light is wrongly computed. The cinematographer desires to work with a 4 to 1 lighting ratio and employs 200 footcandles (2000 lux) light level for a T-4 exposure on Eastman Color Negative with an E.I. 100 (21 DIN). The key light is positioned and adjusted to provide 200 footcandles (2000 lux) at the subject position. The fill light is positioned close to the camera and adjusted to provide the 50 footcandles (500 lux) illumination required for a 4 to 1 key to fill ratio. However, where the beams of *both* lights are superimposed on the player he is illuminated with 250 footcandles (2500 lux). The exposure must be adjusted to T-4.5, rather than the desired T-4. This is the reason why many cinematographers do not realize why an established light level suddenly becomes higher and requires a smaller stop than desired.

The correct lighting technique is to establish the key light with *slightly less intensity* than required so that when the fill light is added it will provide the additional illumination that produces *both* the desired light *intensity* and lighting *ratio*. Both key and fill lights should be adjusted together to achieve proper light balance.

There are exceptions to this method of computing lighting ratio when the key and fill light are *not* superimposed. Back and rear three-quarter key lighting, employed for low key, night and special light effects, positions the key and fill (if a fill light is used)

so that their beams illuminate *different areas* of the subject. The key may produce an edge lighting effect, or side lighting and the fill a soft front lighting. Since the key and fill are *not* superimposed in such lighting set-ups the lighting ratio should be computed on the basis of key to fill light.

Best results for *normal* color scenes are obtained when the subject matter has an *average reflectance,* with some light, some medium and some dark colors, and the scene is illuminated with a low ratio lighting of 2 or 3 to 1. A 4 to 1 ratio may be desirable on scenes with very low color contrast, if a more contrasty effect is required. Such scenes will thus acquire additional overall contrast with lighting contrast, by deepening the shadows. It would be preferable, however, to substitute different colored costumes, furniture, backgrounds or props, that produce greater color contrast, rather than strive to inject subject contrast with high ratio lighting. This may be easily accomplished in the studio or under other controllable conditions. On location, or anytime subject matter cannot be altered, it may be necessary to use a higher lighting contrast to overcome low subject contrast.

An opposite situation occurs outdoors in bright sunlight when lighting contrast is too high and must be lowered for best results. This is accomplished by "scrimming" or diffusing harsh sunlight and/or employing sun reflectors or artificial "booster" lights to lighten shadow areas. Thus the contrast between highlights and shadows is reduced to a more desirable level. Harsh sunlight may result in a 7 or 8 to 1 lighting ratio, but this should be reduced to 3 or 4 to 1 for best overall color reproduction.

The angle of the key light, the sun outdoors or an artificial key light indoors, also determines the lighting contrast. A side or back-light produces greater contrast than a front light because it shadows more of the subject. The greater the angle of the key light in relation to the camera, the greater the lighting ratio. The sun angle produces greater contrast as the camera is moved around to film the scene with side or back-lighting. However, a high sun angle also produces harsh contrast because it shadows the eyes and chins of the players and produces very poor modeling. Newsreels, travelogs, documentary films and home movies, particularly those photographed in tropical countries without the aid of reflectors or booster lights, depict high ratio lighting contrast with burned out faces, black eye sockets and little or no detail under large hat brims.

Color film photographed expressly for television transmission will benefit from very low 1½ to 1 or 2 to 1 lighting ratio. Excessive lighting contrast, except for night scenes or special effects, should be avoided because of the low reflectance range that television can transmit with any degree of fidelity.

Professional cinematographers generally use an incident light meter that either *measures* and/or *evaluates* the intensity of the light falling on the scene. (A *flat disk* is used to *measure* the intensity of a *light source* in either footcandles or lux. A *hemispheric light collector* is used to *evaluate all of the lights* illuminating the subject by integrating their various intensities into a single readout, generally in direct T-Stops.) Interiors are illuminated to a predetermined light level (intensity). This light intensity is based on the ASA or DIN value of the film and is measured in footcandles or lux. A director of photography chooses a particular light level on the basis of depth-of-field desired, power available, particular light effect required, such as high or low key, day or night effect, and whether the film is exposed at its normal speed rating or is to be "pushed" in processing. Working to a fixed incident light level insures consistent flesh tones throughout a sequence, regardless of the type of shot or area filmed. Long shots, medium shots and close-ups are all filmed with the same light level and T-Stop, so general lighting does not have to be altered once it is established for a particular setting. However, close-ups are generally altered, so that principal players are photographed at their best. The key light intensity may be *cheated* slightly on occasion for an exceptionally light or dark face. This may occur in two-shots and pairs of matching close-ups where a dark complexioned man may be photographed together with a very light woman. The key light on each player may be varied up or down to bring the pair into better lighting balance.

Incident light meters, such as the SPECTRA, read directly in lens stops. This is accomplished by inserting a custom-made slide into the meter which takes into account the film speed and exposure time, which is generally 1/50th second. Readings may be made with any professional light meter that reads incident light, such as the GOSSEN LUNA-PRO. The SPECTRA also reads directly in footcandles or lux by exchanging the plastic *hemisphere* for a *flat disk*. Gaffers, and many cameramen, use footcandle and lux incident light meters, such as the GOSSEN TRI-LUX, to read the light intensity. Footcandle and lux readings are particularly beneficial on low light level interiors or night exteriors, where the light intensity may be so low that the needle on a conventional meter barely deflects. Even very low light levels may be read midscale on such meters and variations of a few footcandles or lux are easily adjusted. Direct incident light readings made in this manner are much more precise than reading conventional meters with one-third stop increments. Adjustment of key and fill light may be made with greater accuracy and easily duplicated even days later if a retake is required. Today's ultra-fast color emulsions and low light levels require precise light intensity measure-

ment because the difference of even a few footcandles or lux presents a large error, percentage-wise, under very low light level conditions.

The *Incident Light Calculator* may be used to find the T-stop required for any light level (footcandles or lux) for any film speed. Or, the desired T-stop may be chosen and the calculator will indicate the light intensity required for any film speed. The calculator also provides the fill light intensity required (in T-stops, footcandles or lux) for any desired lighting ratio from 1½:1 to 16:1.

A reflected light meter of the spot reading type, such as the PENTAX or MINOLTA, or the GOSSEN LUNA-PRO with its Variable Angle Spot Meter Attachment, can be very useful for *adjusting* incident light meter readings on scenes that are *not* average. First an incident light reading is taken and then any significant areas, such as "hot" backgrounds (white walls, bald skies, bright windows) or very dark subject matter (dark colors, black rocks, dark walls or backgrounds) may be read with the spot meter. If such areas are significant and detail should be recorded, the incident light reading may be adjusted up or down to compensate. The spot meter is invaluable for reflected light readings on any scene that does not fall into the average 18% mid-scale incident light category. Often a reading inbetween the incident light indication and the reflected light spot meter reading of a significant area, may be used as a compromise T-stop setting. The spot meter is also valuable for reading a face that is very light or very dark, if it is desirous that it be recorded mid-scale.

SCENE LUMINANCE RANGE. The *reflectance ratio* of the various surfaces in the scene *and* the *lighting ratio* are *combined* to determine the scene's *overall contrast* — which is referred to as the *scene luminance range*. It is very important to think of the *various tonal values* in the scene and the *lighting* as separate entities because they may be brought together in various ways to produce almost any desired scene contrast when subject matter, setting and lighting are controllable as in studio filming, or on location when booster lights, scrims and/or reflectors are employed.

*Luminance* is a unit measure of the *strength of the light reflected from a surface*. The unit used is the foot lambert or candelas per square foot (or candelas per square meter). *Luminance* is the product of the *surface's reflectance multiplied by the light intensity*. The word *brightness* is often used to mean luminance. Luminance may be physically measured but *brightness cannot be measured* because it is a purely *subjective visual impression* of the various reflectances in the scene. Brightness is psychological because it is the *mental effect* of a light of a given luminance as per-

ceived under a particular condition. Perception of brightness is roughly a logarithmic phenomenon and thus a visual equivalent of the sound decibel would be more appropriate, if such a term were available. It is proper, therefore, to refer to the scene's luminance range, rather than its brightness range. Reflected light exposure meters are actually *luminance meters*. The *size* of the surface measured and the *distance* of the meter makes no difference if the reading is made of a *uniform area* because the meter indicates the strength of light per unit area. Spot meters are particularly useful for luminance readings because they possess a very narrow viewing angle and can read a small uniform area from a great distance.

The greater the subject reflectance ratio, the higher the lighting ratio, the higher the scene's contrast. Conversely, the lesser the reflectance ratio, the lower the lighting ratio, the lower the scene's contrast. Only subject surfaces of significant area should be considered. Small very light or very dark *accents* may be disregarded in considering overall scene contrast. Although such small areas are pictorially significant, they generally do not influence the scene's overall contrast or reproduction. Since motion pictures are comprised of a series of scenes of varying image sizes, contrast may vary from shot to shot *within* a sequence. A large expanse of "hot" sandy beach in a long shot is eliminated in two-shots of players or individual close-ups. Or, the composition area may be varied by dollying the camera or zooming the lens.

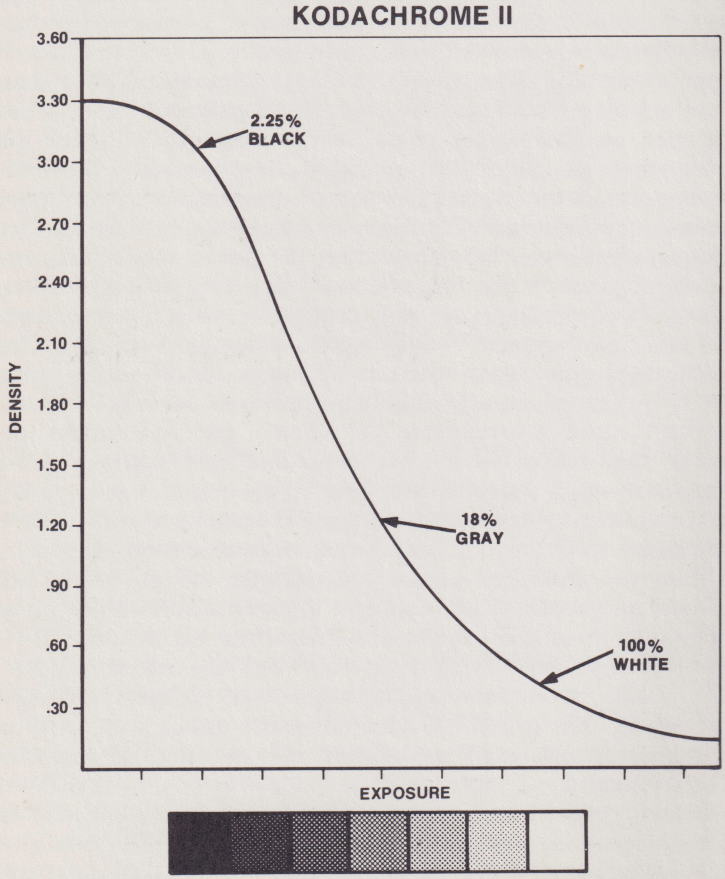
The scene luminance range is defined as *flat* when the subject matter possesses mostly middle tones and few light or dark tones. A scene is *excessively flat* when it contains middle tones only and is minus brilliant highlights and dark shadows. Scenes shot in smoggy, foggy, misty light are generally flat, regardless of the reflectance range of the subject matter. In this instance, atmospheric light conditions determine the scene's contrast regardless of subject reflectance. Such subject matter may be helped by highlight and shadow accents that add a bit of brilliance and snap, such as employing "booster" lights to act as artificial sunlight. Flatness is generally apparent when the subject matter is dull, lifeless, lacks sparkling highlights and specular reflections. The setting thus presents an overall matte appearance. Flat contrast may be produced on interior sets by using flat paint and matte, textured materials for costumes and props, so that few reflections are produced. A little sparkle may be added here and there by painting railings, moldings, or similar areas with glossy paint, or by positioning chrome or other shiny objects in the scene and costuming the players with clothing that pick up highlights and add a bit of sparkle.

*Contrasty* scenes lack middle tones. A scene may appear *excessively contrasty* because it contains many brilliant highlights

and deep black shadows but completely lacks middle tones.

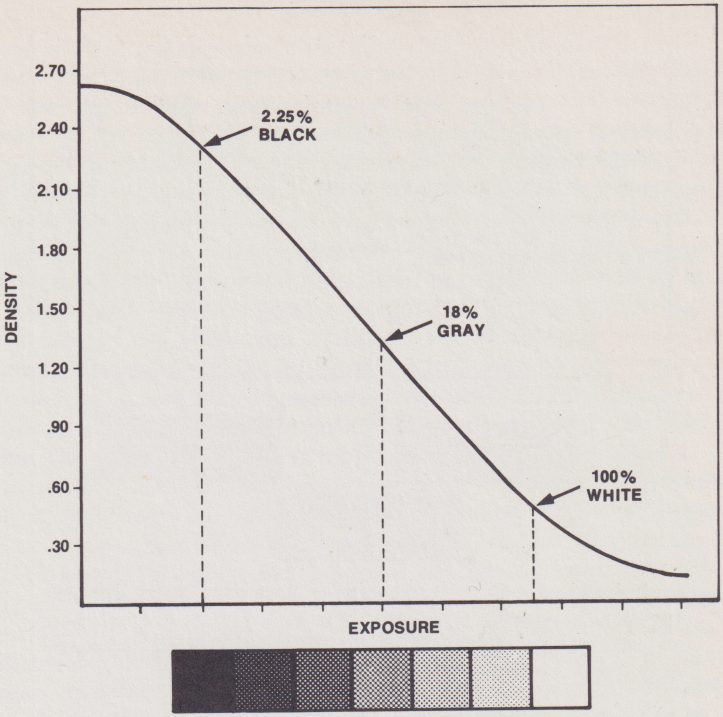
Average contrast color scenes are those ideally described by film manufacturers as having some light, some medium and some dark colors. A 2 or 3 to 1 lighting ratio is recommended for color filming with 4 to 1 as the extreme ratio, so that the combined reflectance of the average scene and the lighting ratio results in the ideal average luminance range that is considered acceptable for reproducing average color contrast.

However, every scene in a color motion picture need *not* be average, particularly when special effects are required, such as high and low key shots, night scenes, certain moody scenes that employ atmospheric effects, or light or color effects. Such scenes



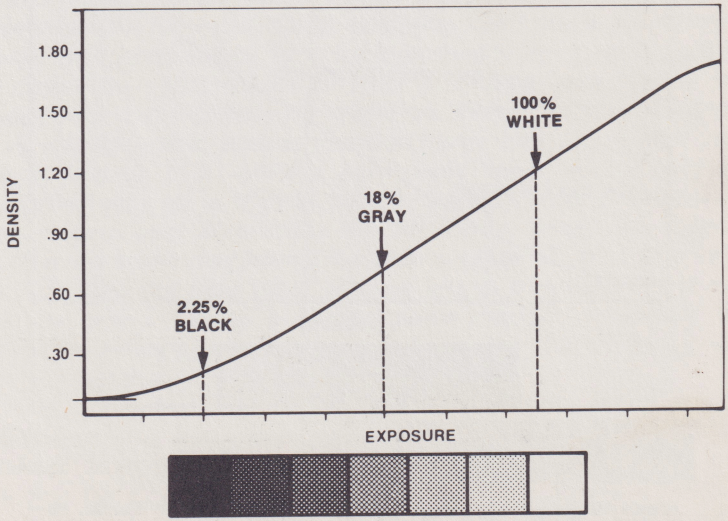

**A reversal color film intended for direct projection. The steep H and D curve indicates a film with high contrast unsuitable for duplication (See: FILM PROCESSING DEFINITIONS, page 108)**

## EKTACHROME COMMERICAL



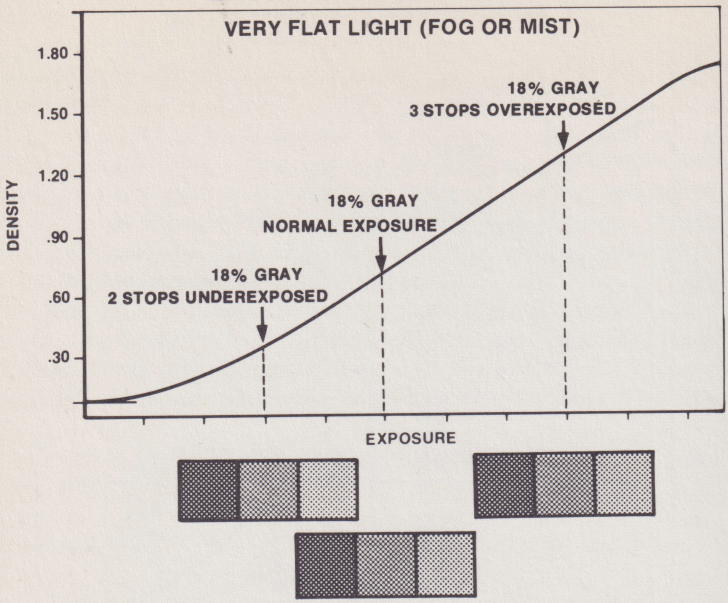

Approximately 45 degree angle of curve indicates softer contrast of system-type color reversal film intended for duplication.

## EASTMAN COLOR NEGATIVE



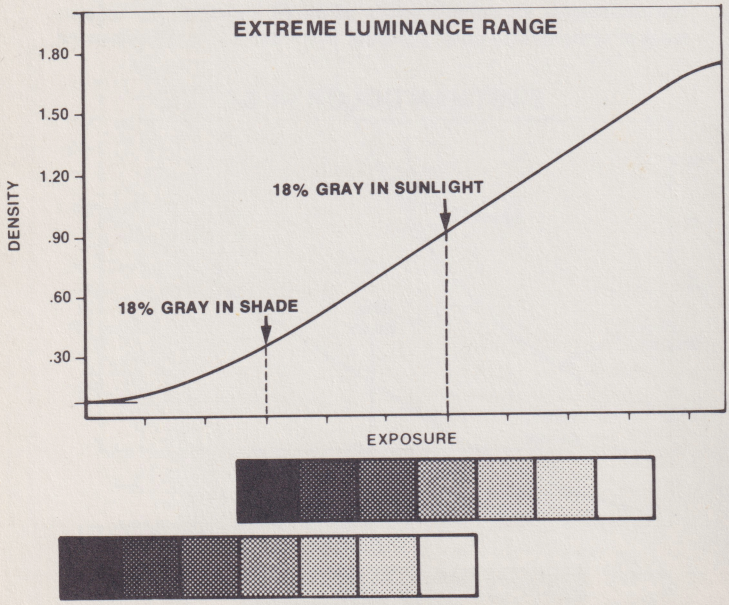

The tonal values of a negative curve are the reverse of the original scene. Highlights have the greatest density, shadows the least density.

## EASTMAN COLOR NEGATIVE




Scenes filmed with very flat light or on a very foggy day will have low luminance range that may be under or overexposed and still fit on straight line portion of curve. Correct exposure will print on center light.

## EASTMAN COLOR NEGATIVE




When subject matter is in sunlight as well as open shade, exposure may be a compromise between the two. It is preferable to favor shadow exposure with negative emulsions because there is one stop more latitude on the highlight end.

often require a flat or contrasty treatment that utilizes scenic elements and/or light effect that produce the desired mood that will involve the viewer emotionally in the picture. It is important, therefore, to recognize flat, average and contrasty scenes in nature, and know how to handle them for any desired result. It may be necessary to *overcome* flatness or excessive contrast for a normal average effect — or it may be necessary to *create* a flat or contrasty scene for a desired special effect.

Outdoors the luminance range may vary from 30:1 to as much as 800:1, with 160:1 a good average. That is, the lightest significant area in the scene has a surface reflecting 160× more light than the darkest significant surface. The average *color negative* can record a contrast range of approximately 200:1 because clear shadow areas are never completely transparent and the blackest highlight areas are never completely opaque, if exposure is approximately correct for the scene. Many professional cinematographers strive to stay within approximately 125:1 (a range of seven stops) when shooting color negative, so that all possible detail in both highlights and shadows will be recorded and reproduced with fidelity. (Cameramen who shoot only reversal color film should realize that a color negative presents reverse tonal values; highlights have the greatest density, shadows the least.) Color reversal film for shooting soft contrast originals intended for duplication has a somewhat shorter range on the order of 100:1 and will produce less contrasty effects if the luminance range of the scene does not exceed 64:1 (a range of six stops). Latitude is greater on the shadow end for almost all color reversal films because detail is lost rapidly in the highlights as overexposure increases. Color television can handle a luminance range of approximately 30:1 for best quality color reproduction. No more than 50:1 should be used for filming color motion pictures produced expressly for television, except for special effects.

A very flat scene, such as found in heavy overcast weather, may be as low as 10:1, while a particularly harsh tropical sunlight condition may go as high as 1000:1. Sunlight angle in relation to the camera also determines the luminance range. An exterior sunlighted scene may have a luminance range of 200:1 in a cross or side light but only 100:1 or even less in frontlight. So, it may require only a change in camera angle outdoors to reduce the scene's contrast by eliminating or reducing the shadow area created by other than front lighting.

The luminance range of any interior or exterior scene may be *translated* into T-Stops for easier visualization of the actual difference in exposure between highlights and shadows by employing the *Cine Exposure Calculator*. Read the *highest significant highlight* area in the scene and place that T-Stop alongside the

"Normal" line. Then read the *lowest significant shadow* area in which detail is desired. Note: do not read shadows that should record dead black — underexposure will accomplish this requirement. Only high and low reflectance areas that should reproduce detail in the screened picture should be read. The T-Stop for the shadow reading will fall alongside the *Cine Factor* which is also an indication of the *luminance range*. Or, read across to the T-Stop column for the difference in actual stops. For example: If the highlight area reads T-16 and the shadow area T-2, the luminance range is 64:1 or a *difference* of 6 stops between highlights and shadows. The actual exposure may be midway, T-5.6, between the two readings, or the highlights may be favored because they are more significant by giving a T-8, or even a T-11 exposure; or the shadow area may be given preference by using a T-4 setting. The important thing is that the exposure latitude of the film may be employed, not to cover exposure errors, but to make greatest use of the film's dynamic exposure range. When the luminance range of the scene is *less* than the latitude of the film, exposure may be adjusted for mid-scale with the assurance that detail will be reproduced in both highlights and shadows. However, when the luminance range of the scene *exceeds* the film's latitude it will be necessary to expose for *either* highlights or shadows. A highlight exposure may produce darkened detailless shadows — a shadow exposure may result in burned out highlights. Or, the scene's luminance range may be lowered by correcting or substituting scenic elements with colors, densities and materials that are less contrasty — or by increasing fill light and/or scrimming "hot" areas. Any or all of these techniques employed individually or in combination will do the trick. Learn to use an incident light meter and a spot meter together with the *Cine Exposure Calculator* to thoroughly analyze the scene's luminance range and adjust the T-Stop to produce the desired screen effect. (NOTE: An extension of the *Cine Exposure Calculator's* scale — to ten stops, 1000:1 luminance range, will be found in the "How to Use the Calculators" text in the TOOL book.)

## EXPOSURE AFFECTS COLOR QUALITY

Over or under exposure not only produces variations in density but affects color quality. Overexposure tends to burn out or *desaturate* colors, so that they appear pastel (diluted with white). This is particularly true with light colors, such as yellow or light blue, or any light color that is much higher than 18% mid-point in reflectance value. Overexposure causes flesh tones to appear too light, so detail is lost in faces and hands. Underexposure causes colors to photograph too dark or more saturated. Dark colors, such as dark greens, dark blues, dark reds, purple, may go com-

pletely black if greatly underexposed. Highlights tend to go pinkish or magenta, and shadows tend to shift bluish or greenish with underexposure. Color shifts due to variations in exposure will be different with color films made by different film manufacturers, and will vary with normal speed and high speed color films made by the same film manufacturer. Comparison tests should be filmed with the various camera films to be used on a production, particularly if special high and low key color effects are involved, or the films are to be pushed in processing, to find out which way the color shifts and whether or not they may be inter-cut without jarring variations in color values.

Latitude of color negative film is greater on the highlight end because density is increased when exposure is increased. A study of the H and D curve shows room on the upper straight line portion of the curve for increased highlight density before blocking up. Underexposure, however, produces loss of shadow detail in the toe portion.

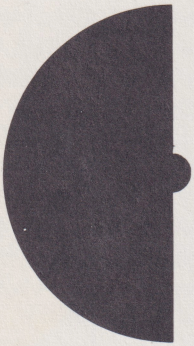
Reversal color film has little latitude because it can record a very limited luminance range. What latitude is available is on the shadow end. Increased exposure causes loss of silver in the highlights which results in thin, detailless highlights. Vast overexposure produces burned out highlights or a "hole" in the image.

Under and overexposure causes opposite effects with original reversal color and negative color camera films. Underexposed reversal has greater density than a normally exposed film. Reversal that receives no exposure at all will appear absolutely black. Overexposing reversal destroys more silver, so as exposure is increased the highlights tend to burn out. Underexposing negative, however, results in less density because less silver is exposed and developed. Overexposure produces greater negative density so highlights tend to block-up or become more opaque. A print, however, from either reversal or negative appears much the same — because underexposure will produce a print with very little shadow detail and overexposure will result in a print with very little highlight density.

Color saturation also affects the *sharpness* of the screened picture. Saturated colors *appear* sharper, particularly if several saturated colors appear together, due to color contrast. There is an apparently sharper *edge quality* or demarcation between saturated colors. Pastel colors appear softer because their edges are "lost" due to lower acutance. This has nothing to do with the sharpness of lenses, film resolution or any other technical problem — it is merely an illusion!

## CINE CAMERA SHUTTERS

The majority of motion picture cameras are equipped with a revolving disk shutter with an open segment. The open portion of the disk exposes the film while it is at rest in the film aperture. The closed portion obscures the light while the intermittently moving film is being pulled down into position for exposure. Cine shutters revolve *parallel* to the film plane in conventional cameras and at *45 degrees* to the film aperture in mirror-reflex cameras — so that the front-surfaced mirror may reflect the taking lens image to the viewfinder during the dark interval. Parallel-type shutters have a single angular opening and revolve once for each exposure. Mirror-reflex shutters are of the *butterfly-type:* they have two equal size angular openings opposite each other, so that their closed portions resemble a butterfly with wings spread. Butterfly shutters expose two frames of film for each revolution.



**180° ROTARY SHUTTER**

**180° BUTTERFLY SHUTTER**

Super 8 and 16mm cine cameras also employ *reciprocating mirror shutter* systems which consist of a moving front-surfaced mirror positioned at 45 degrees in front of the film aperture. The mirror may move either *up-and-down* (guillotine-type) or *side-to-side,* to reflect the taking lens image to the viewfinder while the film is being moved into position for exposure. The moving mirror may act as a shutter *or* it may provide reflex viewing only — in which case it is synchronized with a conventional rotary disk shutter revolving parallel to the film aperture.

Exposure time, expressed in fractions-of-a-second, is determined by the angular opening of the shutter and the number of

frames exposed per second (fr/sec). The smaller the angular opening and/or the faster the frame rate, the shorter the exposure. The following formula may be used to find exposure time:

$$\text{Exposure time} = \frac{\text{shutter opening}}{360 \text{ X fr/sec}}$$

Example: Exposure time for a camera with a 180 degree shutter opening operated at 24 fr/sec:

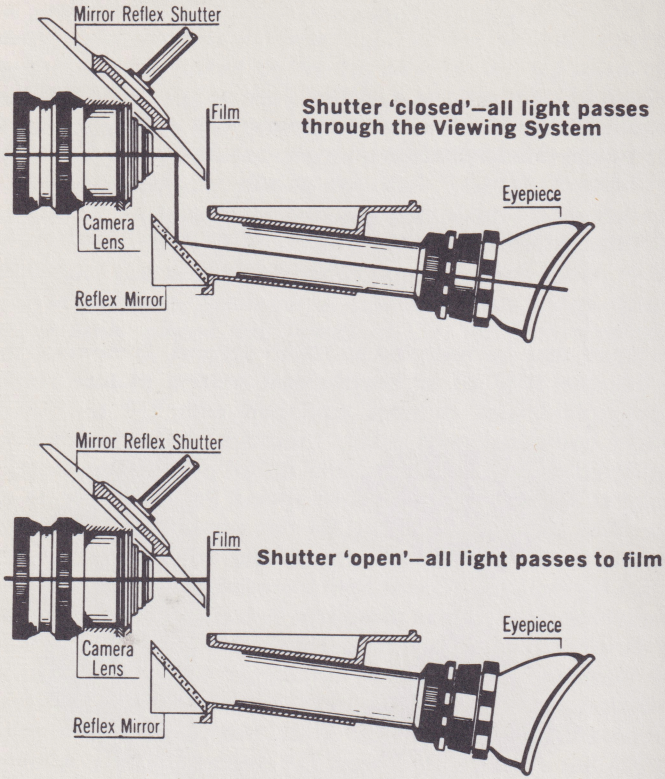
$$\text{Exposure time} = \frac{180}{360 \text{ X } 24} = \frac{180}{8640} = \text{1/48th second}$$

This figure may be rounded to 1/50th second. Remember this figure because 90% of all professional motion picture scenes are photographed with cameras equipped with 170 to 180 degree shutters operating at 24 fr/sec. Therefore, 1/50th second may be considered *normal exposure time* for all practical purposes when filming at normal 24 fr/sec sound speed. Professional cine camera color films are color balanced for this exposure time. Film manufacturers base incident light footcandle and lux exposure tables on this figure, and incident light exposure meters for professional use are calibrated to read directly in T-stops for 1/50th second.

It is advisable, however, to check the camera manual whenever working with a new or unfamiliar camera because several professional and semi-pro cine cameras have shutters with smaller and wider openings. Most 16mm cameras employ 180 degrees but a few models have 235 degree shutters. A few 35mm cameras are equipped with 200 degree shutters. Super 8 models vary greatly, with shutters as wide as 230 degrees, which together with a "speed lens" on the order of T-1.2 and 18 fr/sec amateur silent speed, provides adequate exposure for most existing light filming situations.

Exposure time for mirror-reflex butterfly shutters and reciprocating mirror shutters are expressed as *equivalents* of conventional single angular opening revolving disk shutters. Such shutters are generally defined as having an angular opening equivalent to 180 degrees, for example, if their exposure time is approximately 1/50th second. Camera manuals for cameras with other than conventional rotary shutters generally state the exposure time at various camera frame rates. The equivalent shutter opening may be computed if the exposure time is known for a particular fr/sec rate. A guillotine-type shutter, for example, may expose the film

for 1/60th second at 24 fr/sec. The equivalent shutter opening may be computed as follows: shutter opening = 1/60 X 360 X 24. Equivalent shutter opening = 144 degrees.



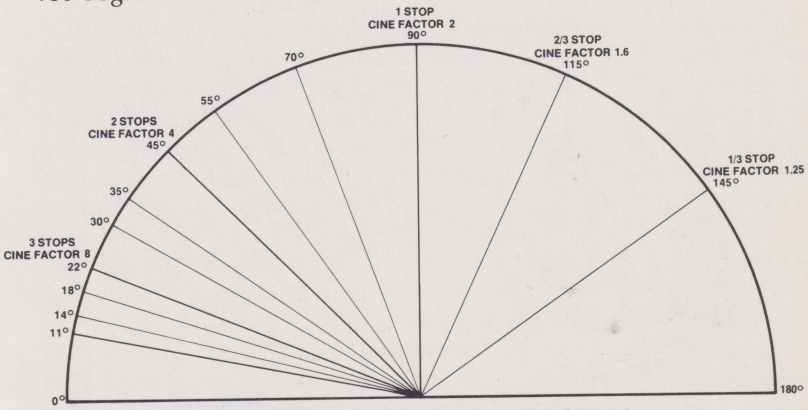

**ARRIFLEX MIRROR REFLEX SHUTTER**

Most cine shutters have fixed openings but a few professional cameras have adjustable shutters. Some models may be adjusted only when the camera is at rest, others may be varied in angular opening while the camera is running. It is wise to check a camera with an adjustable shutter, particularly a rental camera, to be sure the shutter is wide open.

Halving the shutter opening halves the exposure time. Reducing the shutter, for example, from 180 to 90 degrees will cut the exposure from 1/50th to 1/100th second. The professional cinematographer, however, thinks in lens stops, rather than the fractional exposure time, so the lens diaphragm is opened one stop to compensate. Cutting the shutter opening in half again to 45 degrees (1/200th second) would require an additional stop opening. The

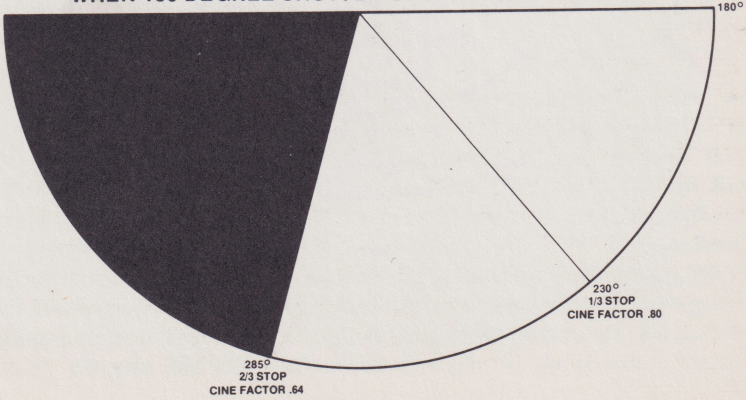
*Cine Exposure Calculator* indicates the exposure increase required in one-third stop increments. If the shutter opening is increased *beyond* 180 degrees there is a *gain* in exposure, so the lens diaphragm must be *closed* to compensate, or the scene may be filmed with proportionately less light. Shutter openings of 200 to 230 degrees permit interior or night filming at lower light levels.

Note that shutter openings work on a logarithmic basis so a fixed number of degrees does *not* result in a fixed increase or decrease in exposure. Only a *single* degree, from 7 to 6, reduces exposure one-third stop — but *fifty* degrees, from 180 to 230, is required for a similar one-third stop difference when the angular opening is considerably wider! The diagrams below demonstrate the amount of angular opening required in one-third stop increments when the shutter opening is decreased or increased from 180 degrees.

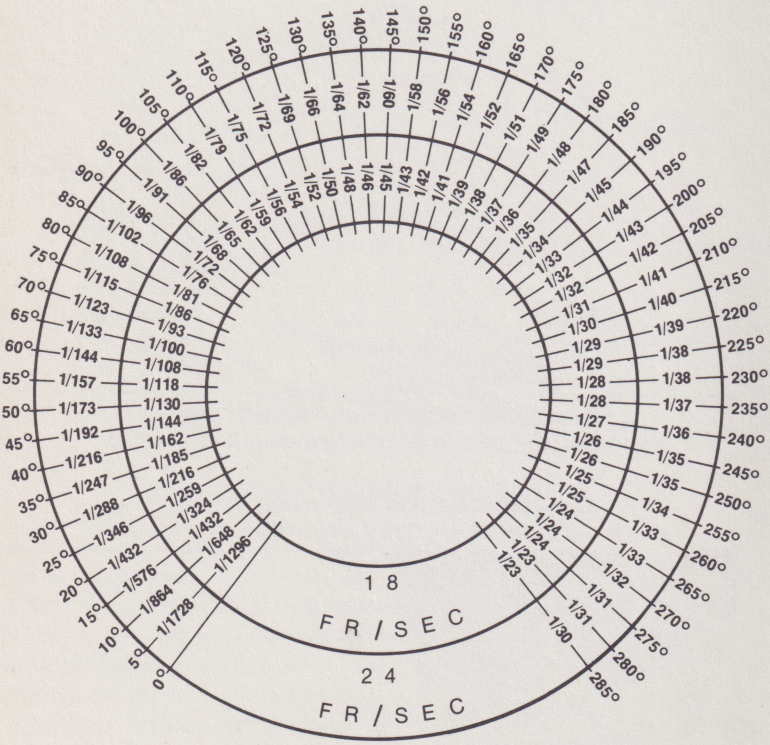



**EXPOSURE LOSS IN ONE-THIRD STOPS WHEN 180 DEGREE SHUTTER OPENING IS REDUCED**

**EXPOSURE GAIN IN ONE-THIRD STOPS WHEN 180 DEGREE SHUTTER OPENING IS INCREASED**



The shutter angle exposure time clock diagram indicates the exposure time for any shutter angle for 24 fr/sec sound speed and 18 fr/sec Super 8 silent speed. The exposure time for any other frame rate, from 2 to 1500 fr/sec, for any shutter angle, may be found by multiplying the exposure time for 24 fr/sec and the desired shutter opening by the Cine Factor for the particular frame rate. For example: the exposure time for 72 fr/sec with a 90 degree shutter opening would be: 96 (exposure at 24 fr/sec for 90 degree shutter is 1/96th second) X 3 (the Cine Factor for 72 fr/sec), which equals 288, or approximately 1/300th second. (Note: Super 8 exposure times may be computed by mentally moving the Cine Factors one space *clockwise* so that *Normal* lines up with 18 fr/sec.)




Reducing the shutter angle results in a shorter exposure and sharper individual pictures of moving subjects. However, it also increases the time interval *between* exposures and records a smaller sampling of the overall action. A 180 degree shutter

records one-half of the action with a permissible degree of blur on moving subjects that actually aids in blending the movement when projected. A 90 degree shutter records only one-quarter of the action, a 45 degree shutter only one-eighth. Reducing the shutter angle records a series of sharper pictures more widely spaced in time. The image displacement between frames on rapidly moving subject matter is often greater than the eye can accommodate — resulting in a breaking up of the image as if shot through a picket fence with a moving camera. This so-called *skipping* or *chatter* effect occurs when the subject moves too fast past the camera, particularly at right angles to the lens, or the camera is panned too fast past a static subject, resulting in a break-up of vertical lines. The smaller the shutter opening, the greater the image displacement on moving camera and/or moving subject shots.

If sharper individual pictures are required, such as frame-by-frame sports analysis films, it is wiser to shoot at a higher frame rate, rather than cut the shutter. Or, cut the shutter, in half for example, to 90 degrees and double the camera frame rate to 48 fr/sec. Reducing the shutter to permit larger lens opening and *decrease* depth-of-field is permissible on more-or-less static set-ups, but it is more advisable to employ neutral density filters.

It is not advisable to reduce a variable shutter to less than 15 degrees because the "slop" in the adjustable blade may introduce variations in exposure from frame to frame, resulting in a flicking image. If a small angular opening is required for special instrumentation cinematography a special shutter with the required angular opening should be cut and mounted in place of the variable shutter. This will insure precise exposure and flickerless images.

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## SPEED OF LIGHT

Light in a vacuum, as in outer space, has a constant speed or velocity. The most recent and precise determination made by Kenneth M. Evenson, using stabilized lasers at the National Bureau of Standards Laboratory in Boulder, Colorado, states the speed of light is: 299,792,456.2 ± 1.1 meters per second or 186,282.3959 statute miles ± approximately 1 yard per second.

The speed of light is less in any substance, such as in the glass of a photographic lens. It is this difference in speed of light passing through varying thicknesses of glass that produces the bending of light rays that make a lens function.

## SUPER 8 COLOR CAMERA FILMS

Although direct projection type Super 8 color camera films, such as Kodachrome II Movie Film, Type A (3400 K), exhibit good contrast, fine definition, high brightness and full color saturation — they are difficult to duplicate faithfully. There is a substantial increase in contrast in the print, causing a loss of detail in the highlight and deep shadow portions of the scene. Certain scene elements may be rendered darker than in the original and some shift in hue may occur. Also, not all labs at the present time have facilities for producing special optical effects (fades, wipes, dissolves, etc.) when printing from Super 8 original film. The release print, therefore, is limited to a series of abrupt scene changes, without the desired embellishments seen in the more professional productions.

If a number of high quality prints are required the best approach is to shoot on a 16mm low-contrast original film, such as Eastman Ektachrome Commercial Film 7252. If only a single Super 8 film is required, then shoot on Super 8. Or, if several prints are needed, medium quality prints from the Super 8 original may, in some cases, be acceptable.

The majority of Super 8 movie cameras now on the market are designed to accept the Super 8 cartridge — which contains a 50 ft. roll of film 8mm wide (column A). A few cameras are available that use spooled 16mm film with Super 8 perforations along both edges of the film (double Super 8). With these cameras the film is exposed along one side, turned over, and then exposed along the other side. After processing, the 16mm film is slit in half and spliced together into one continuous length. The Kodak films available in this second format are listed in Column B.

The ANSI (American) Standard covering Super 8 cartridge speed *notching* (which automatically sets the exposure metering device in the camera) provides for specific film speeds, or ASA Exposure Indexes, of 25, 40, 64, 100, 160, 250, 400, etc. Note that these ASA numbers skip a number so that only every other number is employed. As a result, unless a film speed falls exactly on a notched speed it may be one-third of a stop off. The latitude of the films, in all cases, is sufficient to produce acceptable results. Cameras with manual exposure control, however, should employ the correct Exposure Index for Super 8 camera films.

The following tables show the Super 8 color camera films available in both Super 8 cartridges and Double Super 8 (16mm film double perforated); and also the Exposure Index that Super 8 cartridges are notched for and the Exposure Index that should be employed with manually set cameras. Note that all color film available for Super 8 cartridge cameras are either Type A (3400 K)

or Tungsten (3200 K). The notation "filter" and "no filter" in the table is required because a daylight filter (No. 85) is usually built into the optical path of automatic Super 8 cameras. The positioning of this filter in or out of the camera optical path can be controlled either by the cartridge or by the user, depending on the camera design (see camera instruction manual). Generally, the insertion of a movie light, fitted with a filter key on its base, will push the filter out of the way when filming indoors. The filter may also be removed by the cameraman by inserting a special filter key supplied with the camera.

| KODAK CARTRIDGED SUPER 8 COLOR FILMS FOR AUTOMATIC SUPER 8 CAMERAS | | | |
|---|---|---|---|
| FILM | LIGHT | EXPOSURE INDEX | |
| | | ASA | DIN |
| KODACHROME II Movie Film, Type A | Daylight (filter)<br>Tungsten (no filter) | 25<br>40 | 15<br>17 |
| KODAK EKTACHROME EF Film 7242 (Tungsten) | Daylight (filter)<br>Tungsten (no filter) | 100<br>160 | 21<br>23 |
| KODAK EKTACHROME 160 Movie Film, Type A | Daylight (filter)<br>Tungsten (no filter) | 100<br>160 | 21<br>23 |
| KODAK EKTACHROME 40 Movie Film, Type A | Daylight (filter)<br>Tungsten (no filter) | 25<br>40 | 15<br>17 |
| **GAF & DYNACHROME CARTRIDGED SUPER 8 COLOR FILMS** | | | |
| GAF COLOR Movie Film, Type A | Daylight (filter)<br>Tungsten (no filter) | 25<br>40 | 15<br>17 |
| 3M DYNACHROME Movie Film, Type A | Daylight (filter)<br>Tungsten (no filter) | 25<br>40 | 15<br>17 |
| **KODAK CARTRIDGED SUPER 8 & DOUBLE SUPER 8 COLOR FILMS FOR MANUALLY SET SUPER 8 CAMERAS** | | | |
| KODACHROME II Movie Film, Daylight Type | Daylight (no filter)<br>Tungsten (filter**) | 25<br>8 | 15<br>10 |
| KODACHROME II Movie Film, Type A | Daylight (filter*)<br>Tungsten (no filter) | 25<br>40 | 15<br>17 |
| KODAK EKTACHROME EF Film 7242 (Tungsten) | Daylight (filter*)<br>Tungsten (no filter) | 80<br>125 | 20<br>22 |
| KODAK EKTACHROME 160 Movie Film, Type A | Daylight (filter*)<br>Tungsten (no filter) | 100<br>160 | 21<br>23 |
| KODAK EKTACHROME 40 Movie Film, Type A | Daylight (filter*)<br>Tungsten (no filter) | 25<br>40 | 15<br>17 |

*KODAK WRATTEN Filter No. 85 or 85B (reduces speed 2/3 of a stop).

**KODAK WRATTEN Filter No. 80B (reduces speed 1 2/3 stops).

| KODAK SUPER 8 COLOR CAMERA FILMS | | | | | |
|---|---|---|---|---|---|
| FILM | (A) Single Super 8 (50 Feet of Single-Strand Super 8 Film in a Super 8 Cartridge). | (B) Double Super 8 (16mm Film Perforated Both Edges with Super 8 Perforations) | | | |
| | | | Special Order | | |
| | | 100 Feet on Spool | 200 Feet on Spool | 400 Feet on Core | 1200 Feet on Core |
| KODACHROME II Movie Film, Type A | Yes | Yes | No | No | No |
| KODACHROME II Movie Film, Daylight Type | No | Yes | No | No | No |
| KODAK EKTACHROME EF Film 7242 (Tungsten) | Yes | Yes | Yes* | Yes | No |
| KODAK EKTACHROME 160 Movie Film, Type A | Yes | No | No | No | No |
| KODAK EKTACHROME 40 Movie Film, Type A | Yes | No | No | No | No |

*Also available in 200 ft. single-strand Super 8, magnetic striped, on plastic reel, for WILCAM W-1 Super 8 Sound Camera. S.O. 240, Spec. 429-J. Packed 3 rolls to can, minimum order 3 rolls or multiples of 3.

## GAF COLOR CAMERA FILMS

| FILM NAME & LIGHT BALANCE | TYPE NO. | EXPOSURE INDEX (ASA) | | |
|---|---|---|---|---|
| | 16mm & 35mm | Daylight | 3200 K | 3400 K |
| GAF 64 COLOR REVERSAL (Daylight) | 2311 | 64 (19 DIN) | 16 (with 80A Filter) (13 DIN) | 20 (with 80B Filter) (14 DIN) |
| GAF T100 COLOR REVERSAL (Tungsten) | 2242 | 64 (with 85B Filter) (19 DIN) | 100 (21 DIN) | 80 (with 81A Filter) (20 DIN) |
| GAF 200 COLOR REVERSAL (Daylight) | 2230 | 200 (24 DIN) | 50 (with 80A Filter) (18 DIN) | 64 (with 80B Filter) (19 DIN) |

16mm and 35mm films are latent image marked with film type numbers. Latent image name GAF appears every 12 inches on edge of 16mm film, every 6 inches on 35mm film. 35mm is also latent image emulsion numbered. 35mm films have either a diamond mark or type number latent image exposed at one foot intervals.

All 16 mm films are head punchmarked with word "Color" followed by either a "D" (Daylight) or a "T" (Tungsten).

All 35mm films are head punchmarked with Type Numbers, Emulsion Number, and Roll Number.

All 16mm and 35mm Daylight Color film loads are tail punchmarked with word "Exposed" followed by emulsion number and last two digits of Type Number (Example: Exposed 468-11).

All 16mm color films are available with either one or two rows of perforations. Single perforated stock for camera use should be ordered with "B" wind, 16mm color films are not available with magnetic stripe as either stock item or special order.

16mm 200 ft. spools available on special order only, with a minimum order of two rolls or multiples thereof.

GAF does not recommend "pushing" films in processing more than 1 stop.

## EASTMAN and KODAK COLOR CAMERA FILMS

| FILM NAME & LIGHT BALANCE | FILM NO. | | EXPOSURE INDEX (ASA) | | | IDENTIFICATION | |
|---|---|---|---|---|---|---|---|
| | 16mm | 35mm | Daylight | 3200 K | 3400 K | Letter | End Markings |
| EASTMAN Color Negative II Film (Tungsten) | 7247 | 5247 | 64 (with KODAK Daylight Filter No. 85) (19 DIN) | 100 (21 DIN) | | H (for 35) 7247 (for 16) | |
| EASTMAN EKTACHROME Commercial Film (Tungsten) | 7252 | | 16 (with KODAK Daylight Filter No. 85) (13 DIN) | 25 (15 DIN) | 20 (with KODAK L.B. Filter No. 81) (14 DIN) | ECO | ECO |
| KODAK EKTACHROME MS Film (Daylight) | 7256 | 5256 | 64 (19 DIN) | 16 (with KODAK Conversion Filter No. 80A) (13 DIN) | 20 (with KODAK Conversion Filter No. 80B) (14 DIN) | EMS | EMS |
| KODAK EKTACHROME EF Film (Daylight) | 7241 | 5241 | 160 (23 DIN) | 40 (with KODAK Conversion Filter No. 80A) (17 DIN) | 50 (with KODAK Conversion Filter No 80B) (18 DIN) | EF | Ektachrome EF |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| KODAK EKTACHROME EF Film (Tungsten) | 7242 | 5242 | 80 (with KODAK Daylight Filter No. 85B) (20 DIN) | 125 (22 DIN) | 100 (with KODAK L.B. Filter No. 81A) (21 DIN) | EFB | Ektachrome EF • B |
| KODACHROME II Movie Film (Daylight) | 7265 | | 25 (15 DIN) | | | K | K • II |
| KODACHROME II Movie Film Type A (Tungsten) | 7266 | | 25 (with KODAK Daylight Filter No. 85) (15 DIN) | | 40 (17 DIN) | KA | KA • II |

"Letter precedes edge numbers which are latent-image printed at 16 frame intervals on 35mm and at 20 frame intervals on 16mm film, except Kodachrome II. End marking is punched on both ends of 100 ft. and 200 ft. daylight spools only.

16mm and 35mm darkroom loads are punchmarked at head and tail ends of roll with film code number, emulsion number, and roll number.

All 16mm camera films are available with either one or two rows of perforations. Single perforated film for camera use should be ordered with "B" wind. 16mm Ektachrome MS and EF Films are available with magnetic stripe.

7247 and 5247 films will be generally available early in 1973. Films presently in use are numbered 7254 and 5254.

E.I. is the same. ID Letter "E" for 35mm, "ENF" for 16mm.

## AGFA-GEVAERT COLOR CAMERA FILMS

| FILM NAME & LIGHT BALANCE | TYPE NO. | EXPOSURE INDEX (ASA) | | IDENTIFICATION | |
|---|---|---|---|---|---|
| | 16mm & 35mm | Daylight | Tungsten | Letter | End Markings |
| GEVACOLOR NEGATIVE (Tungsten) | 6.55 | 64 (with CTO 12B or CTO 8B Filter)* (19 DIN) | 100 (21 DIN) | | |
| GEVACHROME ORIGINAL NORMAL SPEED (Tungsten) | 6.00 | 25 (with CTO 12B Filter)* (15 DIN) | 50 (18 DIN) | "N" | 6.00 + Em. No. |
| GEVACHROME ORIGINAL HIGH SPEED (Tungsten) | 6.05B | 64 (with CTO 12B Filter)* (19 DIN) | 125 (22 DIN) | "H" | 6.05B + Em. No. |
| GEVACHROME ORIGINAL DAYLIGHT HS (Daylight) | 6.15 | 160 (23 DIN) | | "D" | 6.15 + Em. No. |

*KODAK Daylight Filter No. 85B may be substituted.

Exposure Index may be doubled for any film by "pushing" 1 stop in processing.

Identification code letter precedes edge numbers which are latent-image printed at 16 frame intervals on 35mm and at 40 frame intervals on 16mm films.

End markings are punchmarked on head end only.

All 16mm reversal films are available with magnetic stripe.

All 16mm camera films are available with either one or two rows of perforations. Single perforated film for camera use should be ordered with "B" wind.

All Gevachrome Color Reversal films are low contrast color original films suitable for making color prints. The relative concentration of dyes is designed for optimum rendering by xenon projection of 5400 K, suitable for television transmission (daylight balance) and also theatrical projection by xenon lamps.

## IMAGE CUT-OFF

The compositional area that the cinematographer frames in the camera viewfinder is *not* always the same area that is projected on the motion picture screen — or scanned on the television tube. It is generally less, and the proportions may differ, dependent upon several factors.

Motion picture films are not always projected or televised in their original width or format — they may be *blown-up* or *reduced* to a larger or smaller film width for various reasons or uses. Also, motion picture are photographed for projection in various *aspect ratios* (height of the projected picture divided into its width). The aspect ratio (AR) used to film the picture is not always the same as that employed to project or televise the film. To further complicate matters motion pictures for theatrical projection are filmed with both *flat* and *squeezed* images.

Conventional *spherical* lenses record *flat,* or *unsqueezed* images. *Anamorphic* lenses, such as employed in the PANAVISION system, produce *squeezed* images. An anamorphic lens *compresses the image horizontally* but does not alter its height. Lenses used to photograph 35mm PANAVISION, and similar 'scope type pictures, employ a *2X squeeze* ratio — which provides the camera aperture with an *apparent width* that is *double* its actual width. In effect, the 35mm camera aperture photographs a squeezed image area that would require a 70mm aperture if a similar picture were filmed with a conventional spherical lens recording a flat image. The projector uses a similar lens or prism system that *unsqueezes* the image and spreads it out to its original width.

Image cut-off begins in projection: all projector apertures, regardless of film width, are slightly smaller all around than camera apertures, to avoid projecting unexposed areas of the original camera film, and to mask any bits of dust, dirt or hairs that may cling to the *edges* of the camera aperture. The percentage of the image cropped by the projector is greater for smaller film formats.

There is only slight cropping when full frame 35mm, 16mm or Super 8 is blown up or reduced from one format to another because all of these formats are basically filmed in the original silent screen's 3 to 4 proportions, or with an aspect ratio of 1.33/1. When films being blown-up or reduced have different aspect ratios, however, portions of the original pictures will be cut off. This occurs when 16mm is blown-up to 35mm widescreen for projection with aspect ratios from 1.66/1 to 1.85/1. Or, when 35mm PANAVISION is *optically scanned* to produce a 16mm or 35mm flat film for television transmission. The 2.35/1

## SUPER 8, 16mm, SUPER 16, 35mm & 65mm CAMERA AND PROJECTOR APERTURES

| FILM FORMAT | APERTURE | INCHES | | MILLIMETERS | |
|---|---|---|---|---|---|
| | | HEIGHT | WIDTH | HEIGHT | WIDTH |
| 35mm FULL | Camera | .735 | .980 | 18.67 | 24.89 |
| 1.33/1 | Projector | .700 | .931 | 17.78 | 23.66 |
| 1.37/1 | Projector | .680 | .931 | 17.26 | 23.66 |
| 1.66/1 | Projector | .561 | .931 | 14.25 | 23.66 |
| 1.75/1 | Projector | .533 | .931 | 13.54 | 23.66 |
| 1.85/1 | Projector | .504 | .931 | 12.79 | 23.66 |
| 35mm ACADEMY | Camera | .631 | .868 | 16.03 | 22.05 |
| 1.37/1 | Projector | .602 | .825 | 15.29 | 20.96 |
| 1.66/1 | Projector | .497 | .825 | 12.62 | 20.96 |
| 1.75/1 | Projector | .472 | .825 | 11.99 | 20.96 |
| 1.85/1 | Projector | .446 | .825 | 11.33 | 20.96 |
| 35mm 2X SQUEEZE | Camera | .735 | .870 | 18.67 | 22.10 |
| 35mm 2X SQUEEZE | Projector | .715 | .839 | 18.16 | 21.31 |
| 35mm 2X Squeeze Groundglass Marks for 70mm Blow-up | | .705 | .776 | 17.91 | 19.71 |
| TECHNISCOPE 35mm 2 Perforations Blow-up to 4 Perf. 2X Squeeze Print | Camera | .373 | .868 | 9.47 | 22.05 |
| | Projector | .355 | .839 | 9.02 | 21.31 |
| 16mm | Camera | .295 | .404 | 7.49 | 10.26 |
| 16mm | Projector | .284 | .380 | 7.21 | 9.65 |
| Super 16 | Camera | .295 | .488 | 7.49 | 12.40 |
| Super 16 Marks for 35mm Blow-up | | | | | |
| 1.66/1 | Projector* | .280 | .464 | 7.10 | 11.78 |
| 1.75/1 | Projector* | .265 | .464 | 6.74 | 11.78 |
| 1.85/1 | Projector* | .251 | .464 | 6.37 | 11.78 |
| SUPER 8 | Camera | .166 | .224 | 4.22 | 5.69 |
| SUPER 8 | Projector | .158 | .209 | 4.01 | 5.31 |
| 65mm | Camera | .906 | 2.072 | 23.01 | 52.63 |
| 70mm | Projector | .868 | 1.913 | 22.05 | 48.59 |
| 65mm Groundglass Marks for 35mm 2X Squeeze Print | | .814 | 1.913 | 20.68 | 48.59 |

*Area of Super 16 original that is blown-up and projected.

AR 'scope format must be reproportioned by cropping to 1.33/1 AR. This requires optically printing the picture so that various areas, generally the middle or either side, are presented.

Image cut-off first reared its ugly head on February 15, 1932 when the *Academy Aperture* was introduced to provide an *industry standard* for filming sound pictures. The full frame silent aperture had to be trimmed on one side to make room for the sound track and the height of the picture was reduced to preserve the 3 to 4 proportions, or 1.33/1 AR of silent films. This resulted in a projection aspect ratio of 1.37/1.

Various flat image wide-screen formats were developed about 1953 to compete with the newly introduced anamorphically squeezed CinemaScope (now obsolete). CinemaScope had an aspect ratio of 2.55/1 when first introduced with magnetic stereophone sound tracks only. This was later reduced to 2.35/1 AR when the picture was trimmed to make room for an optical track also, since many theaters refused to equip their projectors with magnetic sound heads.

The problem of elongating the aspect ratio of flat films so that their screen proportion would approximate that of CinemaScope was solved by reducing the *height* of the projected image, using a shorter focal length projection lens and blowing up the picture onto a larger screen. The fact that the projected picture was much grainier and that approximately 25% of the photographed picture was wasted — was completely ignored! Aspect ratios of 1.66/1, 1.75/1 and 1.85/1 were employed by different producers at various times. The Academy Aperture was retained for both shooting and projection. Marks were simply drawn on the groundglass as a guide to composing the picture for the particular *projection* aspect ratio required. Note that all wide-screen flat films employ aspect ratios based on the projection aperture — *not the camera aperture*. At present most films shot for United States release are generally composed for a 1.85/1 AR, while European release companies generally prefer 1.66/1. Surveys of theaters throughout the world have shown that projection averages 1.75/1AR, so actual screening falls somewhere inbetween 1.66/1 and 1.85/1. The projection problem complicates composing for flat wide-screen films in the camera because the top and bottom of the frame are imaginary lines! The cameraman is at the mercy of the projectionist for both up-and-down framing and choice of mask, and the screen proportions may further mutilate the composition. There is no assurance, therefore, that flat wide-screen films in *any* aspect ratio will appear on the screen as composed in the camera.

American producers do *not* shoot with a so-called *hard matte* in the camera aperture which would result in the desired aspect

ratio on the original negative. All American releases are slated for television showing later and an elongated AR would result in masking at the top and bottom of the television tube. Therefore, the entire Academy Aperture must be "protected" (kept clear of lights, mike booms, scaffolding, etc.) which means that sets must be constructed higher than required for PANAVISION or similar 'scope filming. Although such areas will not be seen on the screen — but will appear on television years later! This also produces a sound problem because the microphone must be kept clear of the Academy Aperture — which requires a wider separation of mike and actors than on 'scope films. A few American producers make an optical dupe negative with a hard matte. Release prints will then be projected with the assurance that no more than the area composed will appear on the screen — but less may appear if the theater's projection system and screen cuts off a part of the picture. The original negative is used later when television prints are required. A few European producers, notably Italians, shoot with a hard matte in the camera, but since they generally film with a 1.66/1 AR this is less of a problem, than with 1.85/1.

Flat wide-screen systems are very wasteful of film because an area only three perforations (instead of four) high is actually projected. Although a smaller area than the Academy Aperture is now projected onto larger screens than before — the projected image is better than ever because of the advances made in color film manufacture. Flat wide-screen pictures could be projected with a three perforation high frame and thus save 25% in film length and considerable transportation charges — particularly with air shipments. This would require recording the sound track for that speed and would also require projector changes from three to four perforation pull down when both 'scope and flat films are projected on the same program. Semi-scope two perforation high pictures (similar to Techniscope as filmed in the camera) could also be projected in an elongated 2.35/1 AR with flat images. A special sound track would be required, however, because of the 45 feet per minute projection speed.

There is really no reason for using an Academy Aperture (or a full aperture with an Academy mask) *in the camera!* The compositional area for either television (safe action) or the particular wide-screen aspect ratio in use should be marked on the focusing groundglass (and the monitoring viewfinder, if the camera is so equipped). A full aperture should be used so that all of the picture area available is photographed. The markings will insure that the picture is properly composed and the printer will mask the sound track area. The fullest possible aperture provides the optical cameraman with extra area, if required, if the film has to

be *flopped* (turned over to reverse screen direction), or if the film has to be reduced or enlarged (if a mike boom should inadvertently appear at the top of the frame), or if the product in a television commercial has to be moved slightly to one side for titling or other reasons. Removing the Academy Aperture will prevent back-lights flaring, kicking or bending off the top edge of the aperture. It will also place the camera aperture edges on three sides farther away from the projector aperture, and prevent any bits of dust, film chips or hairs that may pick up on the edges of the camera aperture from showing on the screen.

A survey of many professional 35mm motion picture cameras has shown that the Academy masking is often incorrect. Many crop more than the standard dimensions and a few cameras have apertures that are not properly centered, or otherwise poorly positioned. This causes further difficulties whenever optical work is required. Since so many original negatives are enlarged or reduced to another format or require optical work of some kind, it is all the more reason to replace the Academy Aperture or the Academy mask that is found in many cameras with full silent picture apertures. Camera manufacturers should take note of this situation and either offer their cameras with or without Academy Apertures, or with silent apertures and Academy masks that may be slipped in for those diehards that insist on shooting with a masked aperture!

PANAVISION, and similar 'scope systems, make the most effective use of the photographed area because there is no waste. All of the area available, other than that required for the sound track, is made use of in photographing and projecting the picture. Thus the picture displays less grain, has greater color saturation because more dye color is projected, and is most brilliant because the projector aperture is larger than flat widescreen apertures and permits throwing more light on the screen. There is a limit to the light intensity that may be projected because of the size of the projector aperture or "hole" that the light must go through to reach the screen.

The area that a cameraman composes in a PANAVISION camera will not be cropped when projected in a modern theater or an older theater with a correctly proportioned screen. Many older theaters, however, are equipped with screens whose proportions and masking are compromises, so that 'scope films are cut off at the sides. Signs, titles, names, inserts or extreme close-ups should be composed within a "safe action" area so that they will not be rendered meaningless if cropped in projection.

Camera and projector aperture dimensions, and groundglass marks, for all film formats are given in tables following this text. Note that the FULL 35mm aperture is used for process back-

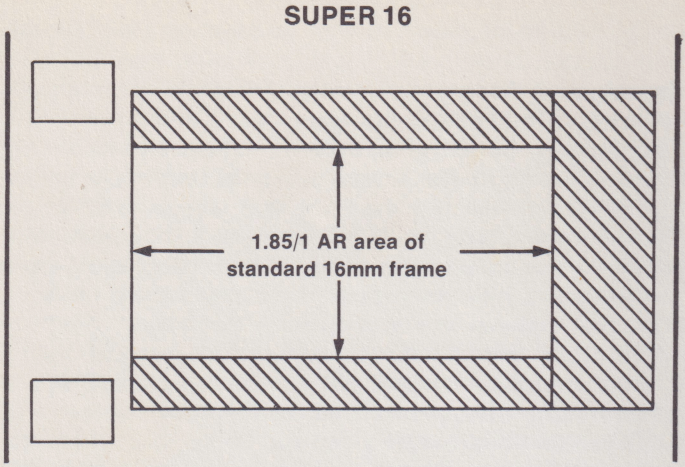
grounds, instrumentation cameras and other purposes where the full negative area should not be wasted. It may also be used for various wide-screen aspect ratios and later optically reduced and recentered for the projector aperture.

The Academy Aperture dimensions should be used *only* for groundglass marks so that the picture is centered and composed for the Academy area but the full silent picture area should be exposed. A contact print will then result in a properly composed picture, with the aspect ratio desired, when projected — providing projection is with the proper mask, and with a proper focal length lens and screen that does not crop the image!

PANAVISION, and similar 'scope systems, present few problems since the picture is generally projected as originally composed, except for older theaters where the sides may be cropped. Groundglass marks are also given for composing 35mm 'scope for later blow-up to 70mm or SUPER PANAVISION. The vast improvements made in color film resolution, grain, color saturation and overall quality make it unnecessary to film in 65mm (for 70mm prints) any longer. A great number of 35mm 'scope theatrical films, however, are blown-up to 70mm for road show, special presentations, drive-in theatres, etc.

Dimensions are provided for Super 8 camera and projector apertures. Dimensions are also given for 65mm camera aperture (for flat unsqueezed pictures) although currently theatrical films are no longer photographed in this format. Many 65mm cameras are still in use, however, for special presentations, such as films for World's Fairs, multi-media projection, and stereo processes. Note that the only difference between 65mm and 70mm lies in the additional width, which is equally divided and placed outside the perforations to accommodate the magnetic stereophonic sound tracks. Perforation center lines and pitch are identical for both film stocks. 65mm may, therefore, be contact printed onto 70mm film. Dimensions are also given for groundglass marks for composing 65mm flat images for *reduction* to 2X squeeze 'scope prints.

Dimensions for Super 16, which employs camera film with a single row of perforations and an enlarged aperture, are based on what the optical printer can handle. Many producers attempt to enlarge the aperture to a greater width than .488" (12.40mm) but most optical printers can handle an area no wider than .485" (12.00mm). Super 16mm permits the cameraman to record approximately 40% more image area — when the film is blown-up to 35mm and projected with a 1.85/1 AR. The format makes fullest use of the 16mm film area available. The pros and cons of filming Super 16 should not be discussed in an article on image cut-off. Needless to say they are many and the problems involved




**Shaded area indicates how Super 16 enlarges picture area approximately 40% by use of single perforated 16mm film and enlarged camera aperture. The elongated frame may be blown-up to 35mm for 1.85/1 AR projection with little loss of image. Note that camera lenses must be recentered for the new aperture and they must be capable of covering the larger picture area without vignetting.**

in shooting Super 16 are yet to be fully resolved. Cameramen shooting Super 16 would be wise to mark their groundglass for 1.85/1 AR and to "protect" the entire frame by keeping the picture clear of all obstructions, such as lights, scaffolding, mike booms, etc. The 35mm blow-up print can then be safely projected in any ratio from 1.66/1 AR to 1.85/1 AR with assurance that nothing important will be cropped — if properly projected.

## TELEVISION IMAGE CUT-OFF

Television tubes present a 3 to 4 proportion picture that is similar to the Academy Aperture aspect ratio. Films shot in Super 8, 16mm, or composed for the 35mm Academy Aperture, will be presented in approximately the same format. Television transmits the picture with slight cropping all round, but most home receivers display *less* picture information. This is caused by accumulated effects of mask shape (rounded corners), off-center scanning or excessive height or width of scanning. Tubes are adjusted so that the image spills over, often in an off-centered manner, because it is easier than precisely adjusting the image to fit the tube. Also both black and white and color tubes have an inherent tendency to shrink the image with age, so an original adjustment that fits the tube area precisely will later display a black border.

Note that all of these maladies are in the *home receiver* and will vary greatly from set to set.

Pictures filmed expressly for television, therefore, should be composed with a prescribed *Safe Action Area* for normal scenes, and a *Safe Title Area* (which is slightly smaller) for titles, inserts and product labels in commercials. These reduced apertures are marked on the viewfinder focusing groundglass, and the monitoring finder, if the camera is so equipped. American National Standards and International Standards Organization (ISO) dimensions for camera, projector, safe action and safe title areas are presented on pages following this section. Double frame 35mm (2" X 2" or 50mm X 50mm) slide dimensions are also given for television station personnel and those producing slides for use on TV.

The reduced image displayed on home receivers presents serious cropping problems for theatrical films and other motion pictures shot for other purposes. Action at the outer edges of such films will be cut off, as will titles composed for the full frame. Particular problems arise when PANAVISION, and similar 'scope films, are transmitted because the picture must not only be *optically scanned* but virtually *re-edited* for television. Various methods are used for picking up different sections of the picture (usually the middle or either side, but systems are in use that offer more choices, including panning during the scene). An editor generally sits in when the original 'scope print is programmed for the optical printer so that he can aid in making decisions on which player to feature at the moment in a two-shot, or what portion of the action is most important, etc.

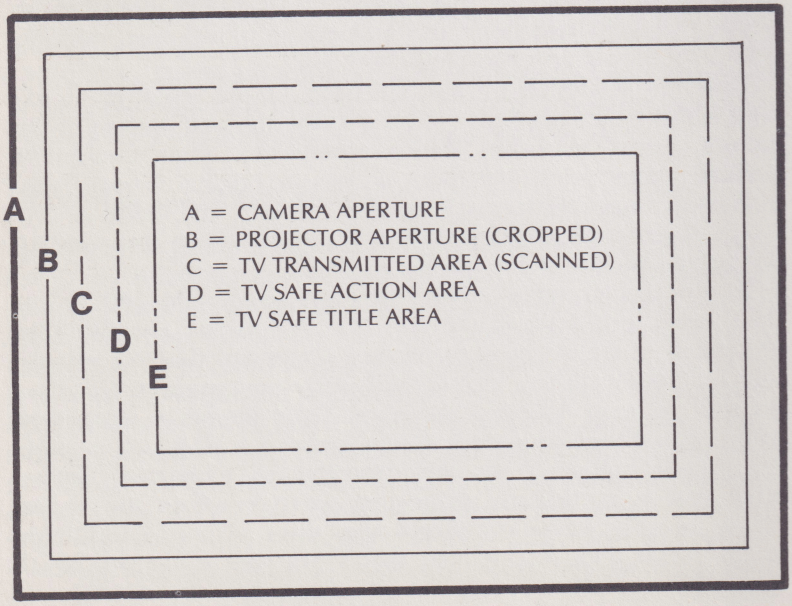
American television networks do not permit masking of any kind which would produce a border at the top and bottom of the picture. Local television stations, however, often transmit a masked 'scope print — in more or less its original format as an elongated image with black borders on top and bottom. The image is generally cheated somewhat, by *not quite unsqueezing* the original picture all the way!

Theatrical film titles suffer the most when televised unless they were originally filmed with the television safe title area in mind — or are placed at the side of a 'scope picture in a manner that fits the TV format. This is particularly noticeable in old movies shot with an Academy Aperture. Titles filmed in 'scope are often transmitted squeezed which works out well unless players appear behind them, this produces an elongated appearance that is particularly distressing when cowboys are shown riding horses! Many producers use titles against nondescript backgrounds and choose type that looks well squeezed, which is a simple solution. Another method is to present the titles in

an elongated 2.35/1 format and optically print in a decorative border on the top and bottom of the frame to fill the entire tube area.

American produces generally make "hot press" or similar type titles on animation cells, so that they may be combined with a static or live action background, or optically filmed with an aerial imaged background in one pass through the camera. The title should be composed within the 9 inch "field" (9 inches wide) and photographed with the camera aperture touching the edges of the 12 inch field. This will insure sufficient safety margin when the title is televised.

The modern cinematographer shooting either a theatrical film or a film for television simply composes for the particular medium. But, there is no way of knowing where or how a picture will be used later. Most theatrical films wind up on television. Many television pictures are released to theaters. Any format may be reduced or blown-up to any other format or transferred to another medium — film is transferred to tape and tape to film and both are later transferred to video cartridges or even Super 8. This is all the more reason to get rid of the Academy Aperture in the camera since most films end up being optically transferred to another format — and the optical cameraman should be given the greatest image area available.



## 35mm FILM
## TELEVISION FILM APERTURES & SAFE AREAS

| | | INCHES | | MILLIMETERS | |
|---|---|---|---|---|---|
| | | HEIGHT | WIDTH | HEIGHT | WIDTH |
| CAMERA | A | .631 | .868 | 16.03 | 22.05 |
| PROJECTOR | B | .612 | .816 | 15.54 | 20.73 |
| TRANSMITTED | C | .594 | .792 | 15.09 | 20.12 |
| SAFE ACTION | D | .535 | .713 | 13.58 | 18.11 |
| SAFE TITLE | E | .475 | .630 | 12.07 | 16.00 |
| ISO SAFE TITLE | E | .515 | .634 | 13.08 | 16.10 |

## 16mm FILM
## TELEVISION FILM APERTURES & SAFE AREAS

| | | INCHES | | MILLIMETERS | |
|---|---|---|---|---|---|
| | | HEIGHT | WIDTH | HEIGHT | WIDTH |
| CAMERA | A | .295 | .404 | 7.49 | 10.26 |
| PROJECTOR | B | .284 | .379 | 7.21 | 9.63 |
| TRANSMITTED | C | .276 | .368 | 7.01 | 9.35 |
| SAFE ACTION | D | .248 | .331 | 6.31 | 8.40 |
| SAFE TITLE | E | .221 | .293 | 5.62 | 7.44 |
| ISO SAFE TITLE | E | .239 | .294 | 6.07 | 7.48 |

## DOUBLE FRAME 35mm (2" x 2") SLIDES
## TELEVISION FILM APERTURES & SAFE AREAS

| | | INCHES | | MILLIMETERS | |
|---|---|---|---|---|---|
| | | HEIGHT | WIDTH | HEIGHT | WIDTH |
| CAMERA* | A | .992 | 1.486 | 25.19 | 37.74 |
| PROJECTOR | B | .945 | 1.417 | 24.00 | 36.00 |
| TRANSMITTED | C | .843 | 1.124 | 21.41 | 28.55 |
| SAFE ACTION | D | .759 | 1.012 | 19.29 | 25.72 |
| SAFE TITLE | E | .674 | .894 | 17.12 | 22.71 |
| TRANSMITTED | C | .846 | 1.125 | 21.49 | 28.58 |
| ISO SAFE ACTION | D | .759 | 1.013 | 19.29 | 25.73 |
| ISO SAFE TITLE | E | .731 | .900 | 18.57 | 22.86 |

*NOTE: 35mm still camera apertures vary in size, but are always larger than 24mm X 36mm. However, slide mounts are standardized at 24mm X 36mm.

## FILM LENGTH CONVERSION TABLE FOR BLOW-UP OR REDUCTION (FEET OR METERS)

Length of original film is *multiplied* by factor indicated to obtain length of blow-up or reduction film.

| ORIGINAL FILM FORMAT | FACTOR | BLOW-UP OR REDUCTION |
|---|---|---|
| Super 8 | 1.8 | 16mm |
| Super 8 | 4.5 | 35mm |
| Super 8 | 5.625 | 65/70mm |
| 16mm | .555 | Super 8 |
| 16mm | 2.5 | 35mm |
| 16mm | 3.125 | 65/70mm |
| 35mm | .222 | Super 8 |
| 35mm | .4 | 16mm |
| 35mm | 1.25 | 65/70mm |
| 65/70mm | .1777 | Super 8 |
| 65/70mm | .32 | 16mm |
| 65/70mm | .8 | 35mm |

## FRAMES PER SECOND = FRAMES PER MINUTE

18 fr/sec = 1080 fr/min

24 fr/sec = 1440 fr/min

25 fr/sec = 1500 fr/min

## FILM TIME & LENGTH CONVERSION TABLES

The film time and length conversion tables on the following pages were especially computed for the Workbook. This is the first time that all film formats from Super 8 to 65/70mm have been displayed in a manner that permits across the board comparison of any film width with any other — at all popular frame rates. Any film width may be compared for either length or running time with any other film width for reduction or blow-up purposes. The length or running time of similar film widths at different frame rates may also be compared.

Super 8 and 16mm are computed for both 18 fr/sec and 24 fr/sec, so that scenes shot silent or at sound speed may be compared, particularly when 16mm silent film is reduced to Super 8. 16mm is also filmed at 18 fr/sec for sports analysis projection, which saves considerable footage. Both 16mm and 35mm are filmed at 24 fr/sec and 25 fr/sec for television use — in countries with 60 Hz and 50Hz line current, respectively. The running time of such films may be compared when they are filmed at one frame rate and projected at the other — which occurs when television films are shipped around the world.

Although 65mm is no longer used for feature films, a considerable number of such pictures exist and are being reduced to smaller formats for television and film cartridge use. 35mm PANAVISION and similar 'scope pictures are also blown-up to 70mm for road show release.

Film length converted to time tables are computed to the nearest second so some lines are duplicated because less than a second is involved. Cameramen may also find these tables valuable for figuring the amount of time for any length of film left in a magazine, or for a short end. Directors think in time so a request for "a 40 second scene" may be quickly converted to length. Length to time tables may also be used by film editors for setting up projection sessions involving a great deal of footage that must be reviewed at normal projection speed. (For double projection speed it is a simple matter to divide the time in half.)

Film editors may also find the film tables useful for figuring where to place theatrical reel breaks, or television film breaks. Lab cost of optical blow-ups or reduction dupe negatives or prints may also be computed by multiplying the cost per foot or per meter by the length of the end product.

All of the film tables are presented in both feet and meters so that they may be used by cameramen and film editors all over the world — and compared, if necessary, to convert from one linear system to the other.

# TIME CONVERTED TO FILM LENGTH • 1 to 60 SECONDS
## FEET & FRAMES

| SEC | SUPER 8 | | 16mm | | | 35mm | | 65/70mm |
|---|---|---|---|---|---|---|---|---|
| | 18 | 24 | 18 | 24 | 25 | 24 | 25 | 24 |
| | Ft/Fr | Ft/Fr | Ft/Fr | Ft/Fr | Ft/Fr | Ft/Fr | Ft/Fr | Ft/Fr |
| 1 | 0 18 | 0 24 | 0 18 | 0 24 | 0 25 | 1 8 | 1 9 | 1 11.2 |
| 2 | 0 36 | 0 48 | 0 36 | 1 8 | 1 10 | 3 | 3 2 | 3 9.6 |
| 3 | 0 54 | 1 0 | 1 14 | 1 32 | 1 35 | 4 8 | 4 11 | 5 8 |
| 4 | 1 0 | 1 24 | 1 32 | 2 16 | 2 20 | 6 | 6 4 | 7 6.4 |
| 5 | 1 18 | 1 48 | 2 10 | 3 0 | 3 5 | 7 8 | 7 13 | 9 4.8 |
| 6 | 1 36 | 2 0 | 2 28 | 3 24 | 3 30 | 9 | 9 6 | 11 3.2 |
| 7 | 1 54 | 2 24 | 3 6 | 4 8 | 4 15 | 10 8 | 10 15 | 13 1.6 |
| 8 | 2 0 | 2 48 | 3 24 | 4 32 | 5 0 | 12 | 12 8 | 15 |
| 9 | 2 18 | 3 0 | 4 2 | 5 16 | 5 25 | 13 8 | 14 1 | 16 11.2 |
| 10 | 2 36 | 3 24 | 4 20 | 6 0 | 6 10 | 15 | 15 10 | 18 9.6 |
| 11 | 2 54 | 3 48 | 4 38 | 6 24 | 6 35 | 16 8 | 17 3 | 20 8 |
| 12 | 3 0 | 4 0 | 5 16 | 7 8 | 7 20 | 18 | 18 12 | 22 6.4 |
| 13 | 3 18 | 4 24 | 5 34 | 7 32 | 8 5 | 19 8 | 20 5 | 24 4.8 |
| 14 | 3 36 | 4 48 | 6 12 | 8 16 | 8 30 | 21 | 21 14 | 26 3.2 |
| 15 | 3 54 | 5 0 | 6 30 | 9 0 | 9 15 | 22 8 | 23 7 | 28 1.6 |
| 16 | 4 0 | 5 24 | 7 8 | 9 24 | 10 0 | 24 | 25 0 | 30 |
| 17 | 4 18 | 5 48 | 7 26 | 10 8 | 10 25 | 25 8 | 26 9 | 31 11.2 |
| 18 | 4 36 | 6 0 | 8 4 | 10 32 | 11 10 | 27 | 28 2 | 33 9.6 |
| 19 | 4 54 | 6 24 | 8 22 | 11 16 | 11 35 | 28 8 | 29 11 | 35 8 |
| 20 | 5 0 | 6 48 | 9 0 | 12 0 | 12 20 | 30 | 31 4 | 37 6.4 |
| 21 | 5 18 | 7 0 | 9 18 | 12 24 | 13 5 | 31 8 | 32 13 | 39 4.8 |
| 22 | 5 36 | 7 24 | 9 36 | 13 8 | 13 30 | 33 | 34 6 | 41 3.2 |
| 23 | 5 54 | 7 48 | 10 14 | 13 32 | 14 15 | 34 8 | 35 15 | 43 1.6 |
| 24 | 6 0 | 8 0 | 10 32 | 14 16 | 15 0 | 36 | 37 8 | 45 |
| 25 | 6 18 | 8 24 | 11 10 | 15 0 | 15 25 | 37 8 | 39 1 | 46 11.2 |
| 26 | 6 36 | 8 48 | 11 28 | 15 24 | 16 10 | 39 | 40 10 | 48 9.6 |
| 27 | 6 54 | 9 0 | 12 6 | 16 8 | 16 35 | 40 8 | 42 3 | 50 8 |
| 28 | 7 0 | 9 24 | 12 24 | 16 32 | 17 20 | 42 | 43 12 | 52 6.4 |
| 29 | 7 18 | 9 48 | 13 2 | 17 16 | 18 5 | 43 8 | 45 5 | 54 4.8 |
| 30 | 7 36 | 10 0 | 13 20 | 18 0 | 18 30 | 45 | 46 14 | 56 3.2 |
| 31 | 7 54 | 10 24 | 13 38 | 18 24 | 19 15 | 46 8 | 48 7 | 58 1.6 |
| 32 | 8 0 | 10 48 | 14 16 | 19 8 | 20 0 | 48 | 50 0 | 60 |
| 33 | 8 18 | 11 0 | 14 34 | 19 32 | 20 25 | 49 8 | 51 9 | 61 11.2 |
| 34 | 8 36 | 11 24 | 15 12 | 20 16 | 21 10 | 51 | 53 2 | 63 9.6 |
| 35 | 8 54 | 11 48 | 15 30 | 21 0 | 21 35 | 52 8 | 54 11 | 65 8 |
| 36 | 9 0 | 12 0 | 16 8 | 21 24 | 22 20 | 54 | 56 4 | 67 6.4 |
| 37 | 9 18 | 12 24 | 16 26 | 22 8 | 23 5 | 55 8 | 57 13 | 69 4.8 |
| 38 | 9 36 | 12 48 | 17 4 | 22 32 | 23 30 | 57 | 59 6 | 71 3.2 |
| 39 | 9 54 | 13 0 | 17 22 | 23 16 | 24 15 | 58 8 | 60 15 | 73 1.6 |
| 40 | 10 0 | 13 24 | 18 0 | 24 0 | 25 0 | 60 | 62 8 | 75 |
| 41 | 10 18 | 13 48 | 18 18 | 24 24 | 25 25 | 61 8 | 64 1 | 76 11.2 |
| 42 | 10 36 | 14 0 | 18 36 | 25 8 | 26 10 | 63 | 65 10 | 78 9.6 |
| 43 | 10 54 | 14 24 | 19 14 | 25 32 | 26 35 | 64 8 | 67 3 | 80 8 |
| 44 | 11 0 | 14 48 | 19 32 | 26 16 | 27 20 | 66 | 68 12 | 82 6.4 |
| 45 | 11 18 | 15 0 | 20 10 | 27 0 | 28 5 | 67 8 | 70 5 | 84 4.8 |
| 46 | 11 36 | 15 24 | 20 28 | 27 24 | 28 30 | 69 | 71 14 | 86 3.2 |
| 47 | 11 54 | 15 48 | 21 6 | 28 8 | 29 15 | 70 8 | 73 7 | 88 1.6 |
| 48 | 12 0 | 16 0 | 21 24 | 28 32 | 30 0 | 72 | 75 0 | 90 |
| 49 | 12 18 | 16 24 | 22 2 | 29 16 | 30 25 | 73 8 | 76 9 | 91 11.2 |
| 50 | 12 36 | 16 48 | 22 20 | 30 0 | 31 10 | 75 | 78 2 | 93 9.6 |
| 51 | 12 54 | 17 0 | 22 38 | 30 24 | 31 35 | 76 8 | 79 11 | 95 8 |
| 52 | 13 0 | 17 24 | 23 16 | 31 8 | 32 20 | 78 | 81 4 | 97 6.4 |
| 53 | 13 18 | 17 48 | 23 34 | 31 32 | 33 5 | 79 8 | 82 13 | 99 4.8 |
| 54 | 13 36 | 18 0 | 24 12 | 32 16 | 33 30 | 81 | 84 6 | 101 3.2 |
| 55 | 13 54 | 18 24 | 24 30 | 33 0 | 34 15 | 82 8 | 85 15 | 103 1.6 |
| 56 | 14 0 | 18 48 | 25 8 | 33 24 | 35 0 | 84 | 87 8 | 105 |
| 57 | 14 18 | 19 0 | 25 26 | 34 8 | 35 25 | 85 8 | 88 1 | 106 11.2 |
| 58 | 14 36 | 19 24 | 26 4 | 34 32 | 36 10 | 87 | 90 10 | 108 9.6 |
| 59 | 14 54 | 19 48 | 26 22 | 35 16 | 36 35 | 88 8 | 92 3 | 110 8 |
| 60 | 15 0 | 20 0 | 27 0 | 36 0 | 37 20 | 90 | 93 12 | 112 6.4 |

# TIME CONVERTED TO FILM LENGTH • 1 to 60 MINUTES
## FEET & FRAMES

| MIN | SUPER 8 | | 16mm | | | 35mm | | 65/70mm |
|---|---|---|---|---|---|---|---|---|
| | 18 | 24 | 18 | 24 | 25 | 24 | 25 | 24 |
| | Ft/Fr | Ft/Fr | Ft/Fr | Ft/Fr | Ft/Fr | Ft/Fr | Ft/Fr | Ft/Fr |
| 1 | 15 | 20 | 27 | 36 | 37 20 | 90 | 93 12 | 112 6.4 |
| 2 | 30 | 40 | 54 | 72 | 75 | 180 | 187 8 | 225 |
| 3 | 45 | 60 | 81 | 108 | 112 20 | 270 | 281 4 | 337 6.4 |
| 4 | 60 | 80 | 108 | 144 | 150 | 360 | 375 | 450 |
| 5 | 75 | 100 | 135 | 180 | 187 20 | 450 | 468 12 | 562 6.4 |
| 6 | 90 | 120 | 162 | 216 | 225 | 540 | 562 8 | 675 |
| 7 | 105 | 140 | 189 | 252 | 262 20 | 630 | 656 4 | 787 6.4 |
| 8 | 120 | 160 | 216 | 288 | 300 | 720 | 750 | 900 |
| 9 | 135 | 180 | 243 | 324 | 337 20 | 810 | 843 12 | 1012 6.4 |
| 10 | 150 | 200 | 270 | 360 | 375 | 900 | 937 8 | 1125 |
| 11 | 165 | 220 | 297 | 396 | 412 20 | 990 | 1031 4 | 1237 6.4 |
| 12 | 180 | 240 | 324 | 432 | 450 | 1080 | 1125 | 1350 |
| 13 | 195 | 260 | 351 | 468 | 487 20 | 1170 | 1218 12 | 1462 6.4 |
| 14 | 210 | 280 | 378 | 504 | 525 | 1260 | 1312 8 | 1575 |
| 15 | 225 | 300 | 405 | 540 | 562 20 | 1350 | 1406 4 | 1687 6.4 |
| 16 | 240 | 320 | 432 | 576 | 600 | 1440 | 1500 | 1800 |
| 17 | 255 | 340 | 459 | 612 | 637 20 | 1530 | 1593 12 | 1912 6.4 |
| 18 | 270 | 360 | 486 | 648 | 675 | 1620 | 1687 8 | 2025 |
| 19 | 285 | 380 | 513 | 684 | 712 20 | 1710 | 1781 4 | 2137 6.4 |
| 20 | 300 | 400 | 540 | 720 | 750 | 1800 | 1875 | 2250 |
| 21 | 315 | 420 | 567 | 756 | 787 20 | 1890 | 1968 12 | 2362 6.4 |
| 22 | 330 | 440 | 594 | 792 | 825 | 1980 | 2062 8 | 2475 |
| 23 | 345 | 460 | 621 | 828 | 862 20 | 2070 | 2156 4 | 2587 6.4 |
| 24 | 360 | 480 | 648 | 864 | 900 | 2160 | 2250 | 2700 |
| 25 | 375 | 500 | 675 | 900 | 937 20 | 2250 | 2343 12 | 2812 6.4 |
| 26 | 390 | 520 | 702 | 936 | 975 | 2340 | 2437 8 | 2925 |
| 27 | 405 | 540 | 729 | 972 | 1012 20 | 2430 | 2531 4 | 3037 6.4 |
| 28 | 420 | 560 | 756 | 1008 | 1050 | 2520 | 2625 | 3150 |
| 29 | 435 | 580 | 783 | 1044 | 1087 20 | 2610 | 2718 12 | 3262 6.4 |
| 30 | 450 | 600 | 810 | 1080 | 1125 | 2700 | 2812 8 | 3375 |
| 31 | 465 | 620 | 837 | 1116 | 1162 20 | 2790 | 2906 4 | 3487 6.4 |
| 32 | 480 | 640 | 864 | 1152 | 1200 | 2880 | 3000 | 3600 |
| 33 | 495 | 660 | 891 | 1188 | 1237 20 | 2970 | 3093 12 | 3712 6.4 |
| 34 | 510 | 680 | 918 | 1224 | 1275 | 3060 | 3187 8 | 3825 |
| 35 | 525 | 700 | 945 | 1260 | 1312 20 | 3150 | 3281 4 | 3937 6.4 |
| 36 | 540 | 720 | 972 | 1296 | 1350 | 3240 | 3375 | 4050 |
| 37 | 555 | 740 | 999 | 1332 | 1387 20 | 3330 | 3468 12 | 4162 6.4 |
| 38 | 570 | 760 | 1026 | 1368 | 1425 | 3420 | 3562 8 | 4275 |
| 39 | 585 | 780 | 1053 | 1404 | 1462 20 | 3510 | 3656 4 | 4387 6.4 |
| 40 | 600 | 800 | 1080 | 1440 | 1500 | 3600 | 3750 | 4500 |
| 41 | 615 | 820 | 1107 | 1476 | 1537 20 | 3690 | 3843 12 | 4612 6.4 |
| 42 | 630 | 840 | 1134 | 1512 | 1575 | 3780 | 3937 8 | 4725 |
| 43 | 645 | 860 | 1161 | 1548 | 1612 20 | 3870 | 4031 4 | 4837 6.4 |
| 44 | 660 | 880 | 1188 | 1584 | 1650 | 3960 | 4125 | 4950 |
| 45 | 675 | 900 | 1215 | 1620 | 1687 20 | 4050 | 4218 12 | 5062 6.4 |
| 46 | 690 | 920 | 1242 | 1656 | 1725 | 4140 | 4312 8 | 5175 |
| 47 | 705 | 940 | 1269 | 1692 | 1762 20 | 4230 | 4406 4 | 5287 6.4 |
| 48 | 720 | 960 | 1296 | 1728 | 1800 | 4320 | 4500 | 5400 |
| 49 | 735 | 980 | 1323 | 1764 | 1837 20 | 4410 | 4593 12 | 5512 6.4 |
| 50 | 750 | 1000 | 1350 | 1800 | 1875 | 4500 | 4687 8 | 5625 |
| 51 | 765 | 1020 | 1377 | 1836 | 1912 20 | 4590 | 4781 4 | 5737 6.4 |
| 52 | 780 | 1040 | 1404 | 1872 | 1950 | 4680 | 4875 | 5850 |
| 53 | 795 | 1060 | 1431 | 1908 | 1987 20 | 4770 | 4968 12 | 5962 6.4 |
| 54 | 810 | 1080 | 1458 | 1944 | 2025 | 4860 | 5062 8 | 6075 |
| 55 | 825 | 1100 | 1485 | 1980 | 2062 20 | 4950 | 5156 4 | 6187 6.4 |
| 56 | 840 | 1120 | 1512 | 2016 | 2100 | 5040 | 5250 | 6300 |
| 57 | 855 | 1140 | 1539 | 2052 | 2137 20 | 5130 | 5343 12 | 6412 6.4 |
| 58 | 870 | 1160 | 1566 | 2088 | 2175 | 5220 | 5437 8 | 6525 |
| 59 | 885 | 1180 | 1593 | 2124 | 2212 20 | 5310 | 5531 4 | 6637 6.4 |
| 60 | 900 | 1200 | 1620 | 2160 | 2250 | 5400 | 5625 | 6750 |

# FILM LENGTH CONVERTED TO TIME • FEET

| FEET | SUPER 8 | | 16mm | | | 35mm | | 65/70mm |
|---|---|---|---|---|---|---|---|---|
| | 18 | 24 | 18 | 24 | 25 | 24 | 25 | 24 |
| | Min/Sec | Min/Sec | Min/Sec | Min/Sec | Min/Sec | Sec | Sec | Sec |
| 1 | 4 | 3 | 2 | 2 | 2 | 1 | 1 | 1 |
| 2 | 8 | 6 | 4 | 3 | 3 | 1 | 1 | 1 |
| 3 | 12 | 9 | 7 | 5 | 5 | 2 | 2 | 2 |
| 4 | 16 | 12 | 9 | 7 | 6 | 3 | 3 | 2 |
| 5 | 20 | 15 | 11 | 8 | 8 | 3 | 3 | 3 |
| 6 | 24 | 18 | 13 | 10 | 10 | 4 | 4 | 3 |
| 7 | 28 | 21 | 16 | 12 | 11 | 5 | 4 | 4 |
| 8 | 32 | 24 | 18 | 13 | 13 | 5 | 5 | 4 |
| 9 | 36 | 27 | 20 | 15 | 14 | 6 | 6 | 5 |
| 10 | 40 | 30 | 22 | 17 | 16 | 7 | 6 | 5 |
| 11 | 44 | 33 | 24 | 18 | 18 | 7 | 7 | 6 |
| 12 | 48 | 36 | 27 | 20 | 19 | 8 | 8 | 6 |
| 13 | 52 | 39 | 29 | 22 | 21 | 9 | 8 | 7 |
| 14 | 56 | 42 | 31 | 23 | 22 | 9 | 9 | 7 |
| 15 | 1 0 | 45 | 33 | 25 | 24 | 10 | 10 | 8 |
| 16 | 1 4 | 48 | 36 | 27 | 26 | 11 | 10 | 9 |
| 17 | 1 8 | 51 | 38 | 28 | 27 | 11 | 11 | 9 |
| 18 | 1 12 | 54 | 40 | 30 | 29 | 12 | 12 | 10 |
| 19 | 1 16 | 57 | 42 | 32 | 30 | 13 | 12 | 10 |
| 20 | 1 20 | 1 0 | 44 | 33 | 32 | 13 | 13 | 11 |
| 21 | 1 24 | 1 3 | 47 | 35 | 34 | 14 | 13 | 11 |
| 22 | 1 28 | 1 6 | 49 | 37 | 35 | 15 | 14 | 12 |
| 23 | 1 32 | 1 9 | 51 | 38 | 37 | 15 | 15 | 12 |
| 24 | 1 36 | 1 12 | 53 | 40 | 38 | 16 | 15 | 13 |
| 25 | 1 40 | 1 15 | 56 | 42 | 40 | 17 | 16 | 13 |
| 26 | 1 44 | 1 18 | 58 | 43 | 42 | 17 | 17 | 14 |
| 27 | 1 48 | 1 21 | 1 0 | 45 | 43 | 18 | 17 | 14 |
| 28 | 1 52 | 1 24 | 1 2 | 47 | 45 | 19 | 18 | 15 |
| 29 | 1 56 | 1 27 | 1 4 | 48 | 46 | 19 | 19 | 16 |
| 30 | 2 0 | 1 30 | 1 7 | 50 | 48 | 20 | 19 | 16 |
| 31 | 2 4 | 1 33 | 1 9 | 52 | 50 | 21 | 20 | 17 |
| 32 | 2 8 | 1 36 | 1 11 | 53 | 51 | 21 | 21 | 17 |
| 33 | 2 12 | 1 39 | 1 13 | 55 | 53 | 22 | 21 | 18 |
| 34 | 2 16 | 1 42 | 1 16 | 57 | 54 | 23 | 22 | 18 |
| 35 | 2 20 | 1 45 | 1 18 | 58 | 56 | 23 | 22 | 19 |
| 36 | 2 24 | 1 48 | 1 20 | 1 0 | 58 | 24 | 23 | 19 |
| 37 | 2 28 | 1 51 | 1 22 | 1 2 | 59 | 25 | 24 | 20 |
| 38 | 2 32 | 1 54 | 1 24 | 1 3 | 1 1 | 25 | 24 | 20 |
| 39 | 2 36 | 1 57 | 1 27 | 1 5 | 1 2 | 26 | 25 | 21 |
| 40 | 2 40 | 2 0 | 1 29 | 1 7 | 1 4 | 27 | 26 | 21 |
| 41 | 2 44 | 2 3 | 1 31 | 1 8 | 1 6 | 27 | 26 | 22 |
| 42 | 2 48 | 2 6 | 1 33 | 1 10 | 1 7 | 28 | 27 | 22 |
| 43 | 2 52 | 2 9 | 1 36 | 1 12 | 1 9 | 29 | 28 | 23 |
| 44 | 2 56 | 2 12 | 1 38 | 1 13 | 1 10 | 29 | 28 | 24 |
| 45 | 3 0 | 2 15 | 1 40 | 1 15 | 1 12 | 30 | 29 | 24 |
| 46 | 3 4 | 2 18 | 1 42 | 1 17 | 1 14 | 31 | 30 | 25 |
| 47 | 3 8 | 2 21 | 1 44 | 1 18 | 1 15 | 31 | 30 | 25 |
| 48 | 3 12 | 2 24 | 1 47 | 1 20 | 1 17 | 32 | 31 | 26 |
| 49 | 3 16 | 2 27 | 1 49 | 1 22 | 1 18 | 33 | 31 | 26 |
| 50 | 3 20 | 2 30 | 1 51 | 1 23 | 1 20 | 33 | 32 | 27 |
| 51 | 3 24 | 2 33 | 1 53 | 1 25 | 1 22 | 34 | 33 | 27 |
| 52 | 3 28 | 2 36 | 1 56 | 1 27 | 1 23 | 35 | 33 | 28 |
| 53 | 3 32 | 2 39 | 1 58 | 1 28 | 1 25 | 35 | 34 | 28 |
| 54 | 3 36 | 2 42 | 2 0 | 1 30 | 1 26 | 36 | 35 | 29 |
| 55 | 3 40 | 2 45 | 2 2 | 1 32 | 1 28 | 37 | 35 | 29 |
| 56 | 3 44 | 2 48 | 2 4 | 1 33 | 1 30 | 37 | 36 | 30 |
| 57 | 3 48 | 2 51 | 2 7 | 1 35 | 1 31 | 38 | 37 | 30 |
| 58 | 3 52 | 2 54 | 2 9 | 1 37 | 1 33 | 39 | 37 | 31 |
| 59 | 3 56 | 2 57 | 2 11 | 1 38 | 1 34 | 39 | 38 | 32 |
| 60 | 4 0 | 3 0 | 2 13 | 1 40 | 1 36 | 40 | 39 | 32 |

# FILM LENGTH CONVERTED TO TIME • FEET

| FEET | SUPER 8 | | 16mm | | | 35mm | | 65/70mm |
|---|---|---|---|---|---|---|---|---|
| | 18 | 24 | 18 | 24 | 25 | 24 | 25 | 24 |
| | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec |
| 61 | 4 4 | 3 3 | 2 16 | 1 42 | 1 38 | 41 | 39 | 33 |
| 62 | 4 8 | 3 6 | 2 18 | 1 43 | 1 39 | 41 | 40 | 33 |
| 63 | 4 12 | 3 9 | 2 20 | 1 45 | 1 41 | 42 | 40 | 34 |
| 64 | 4 16 | 3 12 | 2 22 | 1 47 | 1 42 | 43 | 41 | 34 |
| 65 | 4 20 | 3 15 | 2 24 | 1 48 | 1 44 | 43 | 42 | 35 |
| 66 | 4 24 | 3 18 | 2 27 | 1 50 | 1 46 | 44 | 42 | 35 |
| 67 | 4 28 | 3 21 | 2 29 | 1 52 | 1 47 | 45 | 43 | 36 |
| 68 | 4 32 | 3 24 | 2 31 | 1 53 | 1 49 | 45 | 44 | 36 |
| 69 | 4 36 | 3 27 | 2 33 | 1 55 | 1 50 | 46 | 44 | 37 |
| 70 | 4 40 | 3 30 | 2 36 | 1 57 | 1 52 | 47 | 45 | 37 |
| 71 | 4 44 | 3 33 | 2 38 | 1 58 | 1 54 | 47 | 46 | 38 |
| 72 | 4 48 | 3 36 | 2 40 | 2 0 | 1 55 | 48 | 46 | 39 |
| 73 | 4 52 | 3 39 | 2 42 | 2 2 | 1 57 | 49 | 47 | 39 |
| 74 | 4 56 | 3 42 | 2 44 | 2 3 | 1 58 | 49 | 47 | 40 |
| 75 | 5 0 | 3 45 | 2 47 | 2 5 | 2 0 | 50 | 48 | 40 |
| 76 | 5 4 | 3 48 | 2 49 | 2 7 | 2 2 | 51 | 49 | 41 |
| 77 | 5 8 | 3 51 | 2 51 | 2 8 | 2 3 | 51 | 49 | 41 |
| 78 | 5 12 | 3 54 | 2 53 | 2 10 | 2 5 | 52 | 50 | 42 |
| 79 | 5 16 | 3 57 | 2 56 | 2 12 | 2 6 | 53 | 51 | 42 |
| 80 | 5 20 | 4 0 | 2 58 | 2 13 | 2 8 | 53 | 51 | 43 |
| 81 | 5 24 | 4 3 | 3 0 | 2 15 | 2 10 | 54 | 52 | 43 |
| 82 | 5 28 | 4 6 | 3 2 | 2 17 | 2 11 | 55 | 53 | 44 |
| 83 | 5 32 | 4 9 | 3 4 | 2 18 | 2 13 | 55 | 53 | 44 |
| 84 | 5 36 | 4 12 | 3 7 | 2 20 | 2 14 | 56 | 54 | 45 |
| 85 | 5 40 | 4 15 | 3 9 | 2 22 | 2 16 | 57 | 55 | 45 |
| 86 | 5 44 | 4 18 | 3 11 | 2 23 | 2 18 | 57 | 55 | 46 |
| 87 | 5 48 | 4 21 | 3 13 | 2 25 | 2 19 | 58 | 56 | 47 |
| 88 | 5 52 | 4 24 | 3 16 | 2 27 | 2 21 | 59 | 56 | 47 |
| 89 | 5 56 | 4 27 | 3 18 | 2 28 | 2 22 | 59 | 57 | 48 |
| 90 | 6 0 | 4 30 | 3 20 | 2 30 | 2 24 | 1 0 | 58 | 48 |
| 91 | 6 4 | 4 33 | 3 22 | 2 32 | 2 26 | 1 1 | 58 | 49 |
| 92 | 6 8 | 4 36 | 3 24 | 2 33 | 2 27 | 1 1 | 59 | 49 |
| 93 | 6 12 | 4 39 | 3 27 | 2 35 | 2 29 | 1 2 | 1 0 | 50 |
| 94 | 6 16 | 4 42 | 3 29 | 2 37 | 2 30 | 1 3 | 1 0 | 50 |
| 95 | 6 20 | 4 45 | 3 31 | 2 38 | 2 32 | 1 3 | 1 1 | 51 |
| 96 | 6 24 | 4 48 | 3 33 | 2 40 | 2 34 | 1 4 | 1 2 | 51 |
| 97 | 6 28 | 4 51 | 3 36 | 2 42 | 2 35 | 1 5 | 1 2 | 52 |
| 98 | 6 32 | 4 54 | 3 38 | 2 43 | 2 37 | 1 5 | 1 3 | 52 |
| 99 | 6 36 | 4 57 | 3 40 | 2 45 | 2 38 | 1 6 | 1 4 | 53 |
| 100 | 6 40 | 5 0 | 3 42 | 2 47 | 2 40 | 1 7 | 1 4 | 53 |
| 200 | 13 20 | 10 0 | 7 24 | 5 33 | 5 20 | 2 13 | 2 8 | 1 47 |
| 300 | 20 0 | 15 0 | 11 7 | 8 20 | 8 0 | 3 20 | 3 12 | 2 40 |
| 400 | 26 40 | 20 0 | 14 49 | 11 7 | 10 40 | 4 27 | 4 16 | 3 33 |
| 500 | 33 20 | 25 0 | 18 31 | 13 53 | 13 20 | 5 33 | 5 20 | 4 27 |
| 600 | 40 0 | 30 0 | 22 13 | 16 40 | 16 0 | 6 40 | 6 24 | 5 20 |
| 700 | 46 40 | 35 0 | 25 56 | 19 27 | 18 40 | 7 47 | 7 28 | 6 13 |
| 800 | 53 20 | 40 0 | 29 38 | 22 13 | 21 20 | 8 53 | 8 32 | 7 7 |
| 900 | 60 55 | 45 0 | 33 20 | 25 0 | 24 0 | 10 0 | 9 36 | 8 0 |
| 1,000 | 1 06 40 | 50 0 | 37 2 | 27 47 | 26 40 | 11 7 | 10 40 | 8 53 |
| 2,000 | 2 13 20 | 1 40 0 | 1 14 4 | 55 33 | 53 20 | 22 13 | 21 20 | 17 47 |
| 3,000 | 3 20 0 | 2 30 0 | 1 51 7 | 1 23 20 | 1 20 0 | 33 20 | 32 0 | 26 40 |
| 4,000 | 4 26 40 | 3 20 0 | 2 28 9 | 1 51 7 | 1 46 40 | 44 27 | 42 40 | 35 33 |
| 5,000 | 5 33 20 | 4 10 0 | 3 05 11 | 2 18 53 | 2 13 20 | 55 33 | 53 20 | 44 27 |
| 6,000 | 6 40 0 | 5 00 0 | 3 42 13 | 2 46 40 | 2 40 0 | 1 06 40 | 1 04 0 | 53 20 |
| 7,000 | 7 46 40 | 5 50 0 | 4 19 16 | 3 14 27 | 3 06 40 | 1 17 47 | 1 14 40 | 1 02 13 |
| 8,000 | 8 53 20 | 6 40 0 | 4 56 18 | 3 42 13 | 3 33 20 | 1 28 53 | 1 25 20 | 1 11 7 |
| 9,000 | 10 00 0 | 7 30 0 | 5 33 20 | 4 10 0 | 4 00 0 | 1 40 0 | 1 36 0 | 1 20 0 |
| 10,000 | 11 06 40 | 8 20 0 | 6 10 22 | 4 37 47 | 4 26 40 | 1 51 7 | 1 46 40 | 1 28 53 |

## TIME CONVERTED TO FILM LENGTH • 1 to 60 SECONDS
## METRIC

| SEC | SUPER 8 | | 16mm | | | 35mm | | 65/70mm |
|---|---|---|---|---|---|---|---|---|
| | 18 | 24 | 18 | 24 | 25 | 24 | 25 | 24 |
| 1 | .076 | .102 | 0.137 | 0.183 | 0.191 | .456 | .475 | .570 |
| 2 | .152 | .203 | 0.274 | 0.366 | 0.381 | .912 | .950 | 1.140 |
| 3 | .229 | .305 | 0.411 | 0.549 | 0.572 | 1.368 | 1.425 | 1.710 |
| 4 | .305 | .406 | 0.549 | 0.732 | 0.762 | 1.824 | 1.900 | 2.280 |
| 5 | .381 | .508 | 0.686 | 0.914 | 0.953 | 2.280 | 2.375 | 2.850 |
| 6 | .457 | .610 | 0.823 | 1.097 | 1.143 | 2.736 | 2.850 | 3.420 |
| 7 | .533 | .711 | 0.960 | 1.280 | 1.334 | 3.192 | 3.325 | 3.990 |
| 8 | .610 | .813 | 1.097 | 1.463 | 1.524 | 3.648 | 3.800 | 4.560 |
| 9 | .686 | .915 | 1.234 | 1.646 | 1.715 | 4.104 | 4.275 | 5.130 |
| 10 | .762 | 1.016 | 1.372 | 1.829 | 1.905 | 4.560 | 4.750 | 5.700 |
| 11 | .838 | 1.118 | 1.509 | 2.012 | 2.096 | 5.016 | 5.225 | 6.270 |
| 12 | .915 | 1.219 | 1.646 | 2.195 | 2.286 | 5.472 | 5.700 | 6.840 |
| 13 | .991 | 1.321 | 1.783 | 2.377 | 2.477 | 5.928 | 6.175 | 7.410 |
| 14 | 1.067 | 1.423 | 1.920 | 2.560 | 2.667 | 6.384 | 6.650 | 7.980 |
| 15 | 1.143 | 1.524 | 2.057 | 2.743 | 2.858 | 6.840 | 7.125 | 8.550 |
| 16 | 1.219 | 1.626 | 2.195 | 2.926 | 3.048 | 7.296 | 7.600 | 9.120 |
| 17 | 1.296 | 1.727 | 2.332 | 3.109 | 3.239 | 7.752 | 8.075 | 9.690 |
| 18 | 1.372 | 1.829 | 2.469 | 3.292 | 3.429 | 8.208 | 8.550 | 10.260 |
| 19 | 1.448 | 1.931 | 2.606 | 3.475 | 3.620 | 8.664 | 9.025 | 10.830 |
| 20 | 1.524 | 2.032 | 2.743 | 3.658 | 3.810 | 9.120 | 9.500 | 11.400 |
| 21 | 1.600 | 2.134 | 2.880 | 3.840 | 4.001 | 9.576 | 9.975 | 11.970 |
| 22 | 1.677 | 2.236 | 3.018 | 4.023 | 4.191 | 10.032 | 10.450 | 12.540 |
| 23 | 1.753 | 2.337 | 3.155 | 4.206 | 4.382 | 10.488 | 10.925 | 13.110 |
| 24 | 1.829 | 2.439 | 3.292 | 4.389 | 4.572 | 10.944 | 11.400 | 13.680 |
| 25 | 1.905 | 2.540 | 3.429 | 4.572 | 4.763 | 11.400 | 11.875 | 14.250 |
| 26 | 1.982 | 2.642 | 3.566 | 4.755 | 4.953 | 11.856 | 12.350 | 14.820 |
| 27 | 2.058 | 2.744 | 3.703 | 4.938 | 5.144 | 12.312 | 12.825 | 15.390 |
| 28 | 2.134 | 2.845 | 3.840 | 5.121 | 5.334 | 12.768 | 13.300 | 15.960 |
| 29 | 2.210 | 2.947 | 3.978 | 5.304 | 5.525 | 13.224 | 13.775 | 16.530 |
| 30 | 2.286 | 3.048 | 4.115 | 5.486 | 5.715 | 13.680 | 14.250 | 17.100 |
| 31 | 2.363 | 3.150 | 4.252 | 5.669 | 5.906 | 14.136 | 14.725 | 17.670 |
| 32 | 2.439 | 3.252 | 4.389 | 5.852 | 6.096 | 14.592 | 15.200 | 18.240 |
| 33 | 2.515 | 3.353 | 4.526 | 6.035 | 6.287 | 15.048 | 15.675 | 18.810 |
| 34 | 2.591 | 3.455 | 4.663 | 6.218 | 6.477 | 15.504 | 16.150 | 19.380 |
| 35 | 2.667 | 3.557 | 4.801 | 6.401 | 6.668 | 15.960 | 16.625 | 19.950 |
| 36 | 2.744 | 3.658 | 4.938 | 6.584 | 6.858 | 16.416 | 17.100 | 20.520 |
| 37 | 2.820 | 3.760 | 5.075 | 6.767 | 7.049 | 16.872 | 17.575 | 21.090 |
| 38 | 2.896 | 3.861 | 5.212 | 6.949 | 7.239 | 17.328 | 18.050 | 21.660 |
| 39 | 2.972 | 3.963 | 5.349 | 7.132 | 7.430 | 17.784 | 18.525 | 22.230 |
| 40 | 3.048 | 4.065 | 5.486 | 7.315 | 7.620 | 18.240 | 19.000 | 22.800 |
| 41 | 3.125 | 4.166 | 5.624 | 7.498 | 7.811 | 18.696 | 19.475 | 23.370 |
| 42 | 3.201 | 4.268 | 5.761 | 7.681 | 8.001 | 19.152 | 19.950 | 23.940 |
| 43 | 3.277 | 4.369 | 5.898 | 7.864 | 8.192 | 19.608 | 20.425 | 24.510 |
| 44 | 3.353 | 4.471 | 6.035 | 8.047 | 8.382 | 20.064 | 20.900 | 25.080 |
| 45 | 3.430 | 4.573 | 6.172 | 8.230 | 8.573 | 20.520 | 21.375 | 25.650 |
| 46 | 3.506 | 4.674 | 6.309 | 8.412 | 8.763 | 20.976 | 21.850 | 26.220 |
| 47 | 3.582 | 4.776 | 6.447 | 8.595 | 8.954 | 21.432 | 22.325 | 26.790 |
| 48 | 3.658 | 4.878 | 6.584 | 8.778 | 9.144 | 21.888 | 22.800 | 27.360 |
| 49 | 3.734 | 4.979 | 6.721 | 8.961 | 9.335 | 22.344 | 23.275 | 27.930 |
| 50 | 3.811 | 5.081 | 6.858 | 9.144 | 9.525 | 22.800 | 23.750 | 28.500 |
| 51 | 3.887 | 5.182 | 6.995 | 9.327 | 9.716 | 23.256 | 24.225 | 29.070 |
| 52 | 3.963 | 5.284 | 7.132 | 9.510 | 9.906 | 23.712 | 24.700 | 29.640 |
| 53 | 4.039 | 5.386 | 7.269 | 9.693 | 10.097 | 24.168 | 25.175 | 30.210 |
| 54 | 4.115 | 5.487 | 7.407 | 9.876 | 10.287 | 24.624 | 25.650 | 30.780 |
| 55 | 4.192 | 5.589 | 7.544 | 10.058 | 10.478 | 25.080 | 26.125 | 31.350 |
| 56 | 4.268 | 5.690 | 7.681 | 10.241 | 10.668 | 25.536 | 26.600 | 31.920 |
| 57 | 4.344 | 5.792 | 7.818 | 10.424 | 10.859 | 25.992 | 27.075 | 32.490 |
| 58 | 4.420 | 5.894 | 7.955 | 10.607 | 11.049 | 26.448 | 27.550 | 33.060 |
| 59 | 4.497 | 5.995 | 8.092 | 10.790 | 11.240 | 26.904 | 28.025 | 33.630 |
| 60 | 4.573 | 6.097 | 8.230 | 10.973 | 11.430 | 27.360 | 28.500 | 34.200 |

# TIME CONVERTED TO FILM LENGTH • 1 to 60 MINUTES
## METRIC

| MIN | SUPER 8 | | 16mm | | | 35mm | | 65/70mm |
|---|---|---|---|---|---|---|---|---|
| | 18 | 24 | 18 | 24 | 25 | 24 | 25 | 24 |
| 1 | 4.573 | 6.097 | 8.230 | 10.973 | 11.430 | 27.360 | 28.500 | 34.200 |
| 2 | 9.145 | 12.194 | 16.459 | 21.946 | 22.860 | 54.720 | 57.000 | 68.400 |
| 3 | 13.718 | 18.291 | 24.689 | 32.918 | 34.290 | 82.080 | 85.500 | 102.600 |
| 4 | 18.291 | 24.388 | 32.918 | 43.891 | 45.720 | 109.440 | 114.000 | 136.800 |
| 5 | 22.864 | 30.485 | 41.148 | 54.864 | 57.150 | 136.800 | 142.500 | 171.000 |
| 6 | 27.436 | 36.582 | 49.378 | 65.837 | 68.580 | 164.160 | 171.000 | 205.200 |
| 7 | 32.009 | 42.679 | 57.607 | 76.810 | 80.010 | 191.520 | 199.500 | 239.400 |
| 8 | 36.582 | 48.776 | 65.837 | 87.782 | 91.440 | 218.880 | 228.000 | 273.600 |
| 9 | 41.154 | 54.873 | 74.066 | 98.755 | 102.870 | 246.240 | 256.500 | 307.800 |
| 10 | 45.727 | 60.970 | 82.296 | 109.728 | 114.300 | 273.600 | 285.000 | 342.000 |
| 11 | 50.300 | 67.067 | 90.526 | 120.701 | 125.730 | 300.960 | 313.500 | 376.200 |
| 12 | 54.873 | 73.164 | 98.755 | 131.674 | 137.160 | 328.320 | 342.000 | 410.400 |
| 13 | 59.445 | 79.260 | 106.985 | 142.646 | 148.590 | 355.680 | 370.500 | 444.600 |
| 14 | 64.018 | 85.357 | 115.214 | 153.619 | 160.020 | 383.040 | 399.000 | 478.800 |
| 15 | 68.591 | 91.454 | 123.444 | 164.592 | 171.450 | 410.400 | 427.500 | 513.000 |
| 16 | 73.164 | 97.551 | 131.674 | 175.565 | 182.880 | 437.760 | 456.000 | 547.200 |
| 17 | 77.736 | 103.648 | 139.903 | 186.538 | 194.310 | 465.120 | 484.500 | 581.400 |
| 18 | 82.309 | 109.745 | 148.133 | 197.510 | 205.740 | 492.480 | 513.000 | 615.600 |
| 19 | 86.882 | 115.842 | 156.362 | 208.483 | 217.170 | 519.840 | 541.500 | 649.800 |
| 20 | 91.454 | 121.939 | 164.592 | 219.456 | 228.600 | 547.200 | 570.000 | 684.000 |
| 21 | 96.027 | 128.036 | 172.822 | 230.429 | 240.030 | 574.560 | 598.500 | 718.200 |
| 22 | 100.600 | 134.133 | 181.051 | 241.402 | 251.460 | 601.920 | 627.000 | 752.400 |
| 23 | 105.173 | 140.230 | 189.281 | 252.374 | 262.890 | 629.280 | 655.500 | 786.600 |
| 24 | 109.745 | 146.327 | 197.510 | 263.347 | 274.320 | 656.640 | 684.000 | 820.800 |
| 25 | 114.318 | 152.424 | 205.740 | 274.320 | 285.750 | 684.000 | 712.500 | 855.000 |
| 26 | 118.891 | 158.521 | 213.970 | 285.293 | 297.180 | 711.360 | 741.000 | 889.200 |
| 27 | 123.463 | 164.618 | 222.199 | 296.266 | 308.610 | 738.720 | 769.500 | 923.400 |
| 28 | 128.036 | 170.715 | 230.429 | 307.238 | 320.040 | 766.080 | 798.000 | 957.600 |
| 29 | 132.609 | 176.812 | 238.658 | 318.211 | 331.470 | 793.440 | 826.500 | 991.800 |
| 30 | 137.182 | 182.909 | 246.888 | 329.184 | 342.900 | 820.800 | 855.000 | 1026.000 |
| 31 | 141.754 | 189.006 | 255.118 | 340.157 | 354.330 | 848.160 | 883.500 | 1060.200 |
| 32 | 146.327 | 195.103 | 263.347 | 351.130 | 365.760 | 875.520 | 912.000 | 1094.400 |
| 33 | 150.900 | 201.200 | 271.577 | 362.102 | 377.190 | 902.880 | 940.500 | 1128.600 |
| 34 | 155.472 | 207.297 | 279.806 | 373.075 | 388.620 | 930.240 | 969.000 | 1162.800 |
| 35 | 160.045 | 213.394 | 288.036 | 384.048 | 400.050 | 957.600 | 997.500 | 1197.000 |
| 36 | 164.618 | 219.491 | 296.266 | 395.021 | 411.480 | 984.960 | 1026.000 | 1231.200 |
| 37 | 169.191 | 225.588 | 304.495 | 405.994 | 422.910 | 1012.320 | 1054.500 | 1265.400 |
| 38 | 173.763 | 231.684 | 312.725 | 416.966 | 434.340 | 1039.680 | 1083.000 | 1299.600 |
| 39 | 178.336 | 237.781 | 320.954 | 427.939 | 445.770 | 1067.040 | 1111.500 | 1333.800 |
| 40 | 182.909 | 243.878 | 329.184 | 438.912 | 457.200 | 1094.400 | 1140.000 | 1368.000 |
| 41 | 187.482 | 249.975 | 337.414 | 449.885 | 468.630 | 1121.760 | 1168.500 | 1402.200 |
| 42 | 192.054 | 256.072 | 345.643 | 460.858 | 480.060 | 1149.120 | 1197.000 | 1436.400 |
| 43 | 196.627 | 262.169 | 353.873 | 471.830 | 491.490 | 1176.480 | 1225.500 | 1470.600 |
| 44 | 201.200 | 268.266 | 362.102 | 482.803 | 502.920 | 1203.840 | 1254.000 | 1504.800 |
| 45 | 205.772 | 274.363 | 370.332 | 493.776 | 514.350 | 1231.200 | 1282.500 | 1539.000 |
| 46 | 210.345 | 280.460 | 378.562 | 504.749 | 525.780 | 1258.560 | 1311.000 | 1573.200 |
| 47 | 214.918 | 286.557 | 386.791 | 515.722 | 537.210 | 1285.920 | 1339.500 | 1607.400 |
| 48 | 219.491 | 292.654 | 395.021 | 526.694 | 548.640 | 1313.280 | 1368.000 | 1641.600 |
| 49 | 224.063 | 298.751 | 403.250 | 537.667 | 560.070 | 1340.640 | 1396.500 | 1675.800 |
| 50 | 228.636 | 304.848 | 411.480 | 548.640 | 571.500 | 1368.000 | 1425.000 | 1710.000 |
| 51 | 233.209 | 310.945 | 419.710 | 559.613 | 582.930 | 1395.360 | 1453.500 | 1744.200 |
| 52 | 237.781 | 317.042 | 427.939 | 570.586 | 594.360 | 1422.720 | 1482.000 | 1778.400 |
| 53 | 242.354 | 323.139 | 436.169 | 581.558 | 605.790 | 1450.080 | 1510.500 | 1812.600 |
| 54 | 246.927 | 329.236 | 444.398 | 592.531 | 617.220 | 1477.440 | 1539.000 | 1846.800 |
| 55 | 251.500 | 335.333 | 452.628 | 603.504 | 628.650 | 1504.800 | 1567.500 | 1881.000 |
| 56 | 256.072 | 341.430 | 460.858 | 614.477 | 640.080 | 1532.160 | 1596.000 | 1915.200 |
| 57 | 260.645 | 347.527 | 469.087 | 625.450 | 651.510 | 1559.520 | 1624.500 | 1949.400 |
| 58 | 265.218 | 353.624 | 477.317 | 636.422 | 662.940 | 1586.880 | 1653.000 | 1983.600 |
| 59 | 269.790 | 359.721 | 485.546 | 647.395 | 674.370 | 1614.240 | 1681.500 | 2017.800 |
| 60 | 274.363 | 365.818 | 493.776 | 658.368 | 685.800 | 1641.600 | 1710.000 | 2052.000 |

# FILM LENGTH CONVERTED TO TIME • METRIC

| METERS | SUPER 8 | | 16mm | | | 35mm | | 65/70mm |
|---|---|---|---|---|---|---|---|---|
| | 18 | 24 | 18 | 24 | 25 | 24 | 25 | 24 |
| | Min/Sec | Min/Sec | Min/Sec | Min/Sec | Min/Sec | Min/Sec | Min/Sec | Min/Sec |
| 1 | 13 | 10 | 7 | 5 | 5 | 2 | 2 | 2 |
| 2 | 26 | 20 | 15 | 11 | 10 | 4 | 4 | 4 |
| 3 | 39 | 30 | 22 | 16 | 16 | 7 | 6 | 5 |
| 4 | 52 | 39 | 29 | 22 | 21 | 9 | 8 | 7 |
| 5 | 1 6 | 49 | 36 | 27 | 26 | 11 | 11 | 9 |
| 6 | 1 19 | 59 | 44 | 33 | 31 | 13 | 13 | 11 |
| 7 | 1 32 | 1 9 | 51 | 38 | 37 | 16 | 15 | 12 |
| 8 | 1 45 | 1 19 | 58 | 44 | 42 | 18 | 17 | 14 |
| 9 | 1 58 | 1 29 | 1 6 | 49 | 47 | 20 | 19 | 16 |
| 10 | 2 11 | 1 38 | 1 13 | 55 | 52 | 22 | 21 | 18 |
| 11 | 2 24 | 1 48 | 1 20 | 1 0 | 58 | 24 | 23 | 19 |
| 12 | 2 37 | 1 58 | 1 27 | 1 6 | 1 3 | 26 | 25 | 21 |
| 13 | 2 51 | 2 8 | 1 35 | 1 11 | 1 8 | 29 | 27 | 23 |
| 14 | 3 4 | 2 18 | 1 42 | 1 17 | 1 13 | 31 | 29 | 25 |
| 15 | 3 17 | 2 28 | 1 49 | 1 22 | 1 19 | 33 | 32 | 26 |
| 16 | 3 30 | 2 37 | 1 57 | 1 27 | 1 24 | 35 | 34 | 28 |
| 17 | 3 43 | 2 47 | 2 4 | 1 33 | 1 29 | 37 | 36 | 30 |
| 18 | 3 56 | 2 57 | 2 11 | 1 38 | 1 34 | 39 | 38 | 32 |
| 19 | 4 9 | 3 7 | 2 19 | 1 44 | 1 40 | 42 | 40 | 33 |
| 20 | 4 22 | 3 17 | 2 26 | 1 49 | 1 45 | 44 | 42 | 35 |
| 21 | 4 36 | 3 27 | 2 33 | 1 55 | 1 50 | 46 | 44 | 37 |
| 22 | 4 49 | 3 37 | 2 40 | 2 0 | 1 55 | 48 | 46 | 39 |
| 23 | 5 2 | 3 46 | 2 48 | 2 6 | 2 1 | 50 | 48 | 40 |
| 24 | 5 15 | 3 56 | 2 55 | 2 11 | 2 6 | 53 | 51 | 42 |
| 25 | 5 28 | 4 6 | 3 2 | 2 17 | 2 11 | 55 | 53 | 44 |
| 26 | 5 41 | 4 16 | 3 10 | 2 22 | 2 16 | 57 | 55 | 46 |
| 27 | 5 54 | 4 26 | 3 17 | 2 28 | 2 22 | 59 | 57 | 47 |
| 28 | 6 7 | 4 36 | 3 24 | 2 33 | 2 27 | 1 1 | 59 | 49 |
| 29 | 6 21 | 4 45 | 3 31 | 2 39 | 2 32 | 1 4 | 1 1 | 51 |
| 30 | 6 34 | 4 55 | 3 39 | 2 44 | 2 37 | 1 6 | 1 3 | 53 |
| 31 | 6 47 | 5 5 | 3 46 | 2 50 | 2 43 | 1 8 | 1 5 | 54 |
| 32 | 7 0 | 5 15 | 3 53 | 2 55 | 2 48 | 1 10 | 1 7 | 56 |
| 33 | 7 13 | 5 25 | 4 1 | 3 0 | 2 53 | 1 12 | 1 9 | 58 |
| 34 | 7 26 | 5 35 | 4 8 | 3 6 | 2 58 | 1 15 | 1 12 | 1 0 |
| 35 | 7 39 | 5 44 | 4 15 | 3 11 | 3 4 | 1 17 | 1 14 | 1 1 |
| 36 | 7 52 | 5 54 | 4 22 | 3 17 | 3 9 | 1 19 | 1 16 | 1 3 |
| 37 | 8 5 | 6 4 | 4 30 | 3 22 | 3 14 | 1 21 | 1 18 | 1 5 |
| 38 | 8 19 | 6 14 | 4 37 | 3 28 | 3 19 | 1 23 | 1 20 | 1 7 |
| 39 | 8 32 | 6 24 | 4 44 | 3 33 | 3 25 | 1 26 | 1 22 | 1 8 |
| 40 | 8 45 | 6 34 | 4 52 | 3 39 | 3 30 | 1 28 | 1 24 | 1 10 |
| 41 | 8 58 | 6 43 | 4 59 | 3 44 | 3 35 | 1 30 | 1 26 | 1 12 |
| 42 | 9 11 | 6 53 | 5 6 | 3 50 | 3 40 | 1 32 | 1 28 | 1 14 |
| 43 | 9 24 | 7 3 | 5 14 | 3 55 | 3 46 | 1 34 | 1 31 | 1 15 |
| 44 | 9 37 | 7 13 | 5 21 | 4 1 | 3 51 | 1 36 | 1 33 | 1 17 |
| 45 | 9 50 | 7 23 | 5 28 | 4 6 | 3 56 | 1 39 | 1 35 | 1 19 |
| 46 | 10 4 | 7 33 | 5 35 | 4 12 | 4 1 | 1 41 | 1 37 | 1 21 |
| 47 | 10 17 | 7 43 | 5 43 | 4 17 | 4 7 | 1 43 | 1 39 | 1 22 |
| 48 | 10 30 | 7 52 | 5 50 | 4 22 | 4 12 | 1 45 | 1 41 | 1 24 |
| 49 | 10 43 | 8 2 | 5 57 | 4 28 | 4 17 | 1 47 | 1 43 | 1 26 |
| 50 | 10 56 | 8 12 | 6 5 | 4 33 | 4 22 | 1 50 | 1 45 | 1 28 |
| 51 | 11 9 | 8 22 | 6 12 | 4 39 | 4 28 | 1 52 | 1 47 | 1 29 |
| 52 | 11 22 | 8 32 | 6 19 | 4 44 | 4 33 | 1 54 | 1 49 | 1 31 |
| 53 | 11 35 | 8 42 | 6 26 | 4 50 | 4 38 | 1 56 | 1 52 | 1 33 |
| 54 | 11 49 | 8 51 | 6 34 | 4 55 | 4 43 | 1 58 | 1 54 | 1 35 |
| 55 | 12 2 | 9 1 | 6 41 | 5 1 | 4 49 | 2 1 | 1 56 | 1 36 |
| 56 | 12 15 | 9 11 | 6 48 | 5 6 | 4 54 | 2 3 | 1 58 | 1 38 |
| 57 | 12 28 | 9 21 | 6 56 | 5 12 | 4 59 | 2 5 | 2 0 | 1 40 |
| 58 | 12 41 | 9 31 | 7 3 | 5 17 | 5 4 | 2 7 | 2 2 | 1 42 |
| 59 | 12 54 | 9 41 | 7 10 | 5 23 | 5 10 | 2 9 | 2 4 | 1 44 |
| 60 | 13 7 | 9 50 | 7 17 | 5 28 | 5 15 | 2 12 | 2 6 | 1 45 |

# FILM LENGTH CONVERTED TO TIME • METRIC

| METERS | SUPER 8 | | 16mm | | | 35mm | | 65/70mm |
|---|---|---|---|---|---|---|---|---|
| | 18 | 24 | 18 | 24 | 25 | 24 | 25 | 24 |
| | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec | Hr/Min/Sec |
| 61 | 13 20 | 10 0 | 7 25 | 5 34 | 5 20 | 2 14 | 2 8 | 1 47 |
| 62 | 13 34 | 10 10 | 7 32 | 5 39 | 5 25 | 2 16 | 2 11 | 1 49 |
| 63 | 13 47 | 10 20 | 7 39 | 5 44 | 5 31 | 2 18 | 2 13 | 1 51 |
| 64 | 14 0 | 10 30 | 7 47 | 5 50 | 5 36 | 2 20 | 2 15 | 1 52 |
| 65 | 14 13 | 10 40 | 7 54 | 5 55 | 5 41 | 2 23 | 2 17 | 1 54 |
| 66 | 14 26 | 10 50 | 8 1 | 6 1 | 5 46 | 2 25 | 2 19 | 1 56 |
| 67 | 14 39 | 10 59 | 8 8 | 6 6 | 5 52 | 2 27 | 2 21 | 1 58 |
| 68 | 14 52 | 11 9 | 8 16 | 6 12 | 5 57 | 2 29 | 2 23 | 1 59 |
| 69 | 15 5 | 11 19 | 8 23 | 6 17 | 6 2 | 2 31 | 2 25 | 2 1 |
| 70 | 15 18 | 11 29 | 8 30 | 6 23 | 6 7 | 2 34 | 2 27 | 2 3 |
| 71 | 15 32 | 11 39 | 8 38 | 6 28 | 6 13 | 2 36 | 2 29 | 2 5 |
| 72 | 15 45 | 11 49 | 8 45 | 6 34 | 6 18 | 2 38 | 2 32 | 2 6 |
| 73 | 15 58 | 11 58 | 8 52 | 6 39 | 6 23 | 2 40 | 2 34 | 2 8 |
| 74 | 16 11 | 12 8 | 9 0 | 6 45 | 6 28 | 2 42 | 2 36 | 2 10 |
| 75 | 16 24 | 12 18 | 9 7 | 6 50 | 6 34 | 2 44 | 2 38 | 2 12 |
| 76 | 16 37 | 12 28 | 9 14 | 6 56 | 6 39 | 2 47 | 2 40 | 2 13 |
| 77 | 16 50 | 12 38 | 9 21 | 7 1 | 6 44 | 2 49 | 2 42 | 2 15 |
| 78 | 17 3 | 12 48 | 9 29 | 7 7 | 6 49 | 2 51 | 2 44 | 2 17 |
| 79 | 17 17 | 12 57 | 9 36 | 7 12 | 6 55 | 2 53 | 2 46 | 2 19 |
| 80 | 17 30 | 13 7 | 9 43 | 7 17 | 7 0 | 2 55 | 2 48 | 2 20 |
| 81 | 17 43 | 13 17 | 9 51 | 7 23 | 7 5 | 2 58 | 2 51 | 2 22 |
| 82 | 17 56 | 13 27 | 9 58 | 7 28 | 7 10 | 3 0 | 2 53 | 2 24 |
| 83 | 18 9 | 13 37 | 10 5 | 7 34 | 7 16 | 3 2 | 2 55 | 2 26 |
| 84 | 18 22 | 13 47 | 10 12 | 7 39 | 7 21 | 3 4 | 2 57 | 2 27 |
| 85 | 18 35 | 13 56 | 10 20 | 7 45 | 7 26 | 3 6 | 2 59 | 2 29 |
| 86 | 18 48 | 14 6 | 10 27 | 7 50 | 7 31 | 3 9 | 3 1 | 2 31 |
| 87 | 19 2 | 14 16 | 10 34 | 7 56 | 7 37 | 3 11 | 3 3 | 2 33 |
| 88 | 19 15 | 14 26 | 10 42 | 8 1 | 7 42 | 3 13 | 3 5 | 2 34 |
| 89 | 19 28 | 14 36 | 10 49 | 8 7 | 7 47 | 3 15 | 3 7 | 2 36 |
| 90 | 19 41 | 14 46 | 10 56 | 8 12 | 7 52 | 3 17 | 3 9 | 2 38 |
| 91 | 19 54 | 14 56 | 11 3 | 8 18 | 7 58 | 3 20 | 3 12 | 2 40 |
| 92 | 20 7 | 15 5 | 11 11 | 8 23 | 8 3 | 3 22 | 3 14 | 2 41 |
| 93 | 20 20 | 15 15 | 11 18 | 8 29 | 8 8 | 3 24 | 3 16 | 2 43 |
| 94 | 20 33 | 15 25 | 11 25 | 8 34 | 8 13 | 3 26 | 3 18 | 2 45 |
| 95 | 20 47 | 15 35 | 11 33 | 8 39 | 8 19 | 3 28 | 3 20 | 2 47 |
| 96 | 21 0 | 15 45 | 11 40 | 8 45 | 8 24 | 3 31 | 3 22 | 2 48 |
| 97 | 21 13 | 15 55 | 11 47 | 8 50 | 8 29 | 3 33 | 3 24 | 2 50 |
| 98 | 21 26 | 16 4 | 11 54 | 8 56 | 8 34 | 3 35 | 3 26 | 2 52 |
| 99 | 21 39 | 16 14 | 12 2 | 9 1 | 8 40 | 3 37 | 3 28 | 2 54 |
| 100 | 21 52 | 16 24 | 12 9 | 9 7 | 8 45 | 3 39 | 3 31 | 2 55 |
| 200 | 43 44 | 32 48 | 24 18 | 18 14 | 17 30 | 7 19 | 7 1 | 5 51 |
| 300 | 1 05 36 | 49 12 | 36 27 | 27 20 | 26 15 | 10 58 | 10 32 | 8 46 |
| 400 | 1 27 29 | 1 05 36 | 48 36 | 36 27 | 35 0 | 14 37 | 14 2 | 11 42 |
| 500 | 1 49 21 | 1 22 0 | 1 00 45 | 45 34 | 43 45 | 18 16 | 17 33 | 14 37 |
| 600 | 2 11 13 | 1 38 25 | 1 12 54 | 54 41 | 52 30 | 21 56 | 21 3 | 17 33 |
| 700 | 2 33 5 | 1 54 49 | 1 25 4 | 1 03 48 | 1 01 15 | 25 35 | 24 34 | 20 28 |
| 800 | 2 54 57 | 2 11 13 | 1 37 13 | 1 12 54 | 1 09 59 | 29 14 | 28 4 | 23 24 |
| 900 | 3 16 49 | 2 27 37 | 1 49 22 | 1 22 1 | 1 18 44 | 32 54 | 31 35 | 26 19 |
| 1,000 | 3 38 41 | 2 44 1 | 2 01 31 | 1 31 8 | 1 27 29 | 36 33 | 35 5 | 29 14 |
| 2,000 | 7 17 23 | 5 28 2 | 4 03 2 | 3 02 16 | 2 54 59 | 1 13 6 | 1 10 11 | 58 29 |
| 3,000 | 10 56 4 | 8 12 3 | 6 04 32 | 4 33 24 | 4 22 28 | 1 49 39 | 1 45 16 | 1 27 43 |
| 4,000 | 14 34 45 | 10 56 4 | 8 06 3 | 6 04 32 | 5 49 57 | 2 26 12 | 2 20 21 | 1 56 58 |
| 5,000 | 18 13 26 | 13 40 5 | 10 07 34 | 7 35 40 | 7 18 27 | 3 02 45 | 2 55 26 | 2 26 12 |
| 6,000 | 21 52 8 | 16 24 6 | 12 09 5 | 9 06 48 | 8 44 56 | 3 39 18 | 3 30 32 | 2 55 26 |
| 7,000 | 25 30 49 | 19 08 7 | 14 10 35 | 10 37 56 | 10 12 25 | 4 15 51 | 4 05 37 | 3 24 41 |
| 8,000 | 29 09 30 | 21 52 8 | 16 12 6 | 12 09 5 | 11 39 55 | 4 52 24 | 4 40 42 | 3 53 55 |
| 9,000 | 32 48 12 | 24 36 9 | 18 13 37 | 13 40 13 | 13 07 24 | 5 28 57 | 5 15 47 | 4 23 9 |
| 10,000 | 36 26 53 | 27 20 10 | 20 15 8 | 15 11 21 | 14 34 53 | 6 05 30 | 5 50 53 | 4 52 24 |

## PLUS DIOPTER LENSES

Plus diopter lenses are positive supplementary lenses, generally of a weak meniscus type, which may be positioned in front of a fixed focal length or zoom lens to permit sharp focusing at very close camera-to-subject distances. Plus diopters *shorten* the normal lens' focal length and thus permit *closer focusing* and *larger* images. Although a few modern cine cameras are equipped with zoom lenses that permit focusing as close as one millimeter, the majority of professional zoom lenses require plus diopter lenses for sharp focusing closer then approximately 60 inches, or 1.5 meters.

Plus diopter lens power is expressed in metric values so cameramen using feet and inches should strive to understand the original metric designation, which is much simpler. The plus sign indicates a positive, or converging lens. The power of a plus diopter is the reciprocal of the lens focal length in meters. A +1 lens, for example, has a focal length of 1 meter (approximately 40 inches), and will focus a sharp image of an object at this distance — by itself! When positioned in front of a conventional fixed focal length lens or a zoom lens, focused on infinity, it will record a sharp image at 1 meter distance. Focusing the camera lens closer then infinity will deliver sharp images at closer distances. (*See:* PLUS DIOPTER RULER)

A +2 diopter has a focal length of 1/2 meter (50 centimeters or 500 millimeters), or approximately 20 inches. A +3 focuses at 1/3 meter (333mm), or approximately 13 inches; down to a +10, which produces sharp images at 1/10th of a meter or 100mm, about 4 inches. A simple way to remember, for those using inches, is to consider the plus diopter whole number as a *fraction of a meter* — and to divide that fraction into 40 inches. Thus a +2, for example, is 1/2 of 40 inches, and may be sharply focused at 20 inches, when the camera lens is set at infinity. Subject distance is measured from the front of the lens, not from the film plane.

Valuable production time may be saved if the box or case for each diopter is marked not only with its power, but also its focusing range. For example: +2: 333mm to 500mm, or 13" to 20". It is then a simple procedure to position the camera and check the image for size and zooming effect, even though blurred, and then choose the plus diopter required by simply measuring the diopter-to subject distance. The correct power diopter may then be positioned in front of the lens with the assurance that the image will be sharp.

Plus diopters may be used together, in which case their combined power is practically equal to the sum of both powers. A +1 and a +2 = +3. An entire series need not be purchased. A few low

power diopters may be combined to produce higher power lenses. Whenever diopter lenses are used in combination, the highest power should be positioned nearest the camera lens. The convex (outward curve) of the lens should be toward the subject. If an arrow is inscribed on the rim it should point toward the subject. All supplementary lenses degrade the image to some extent. The higher the power of any supplementary lens, the greater this degradation. Only the lower power diopters, up to +3, and no higher than +4, are practical for general use, depending on image quality desired. Closing the lens diaphragm at least two stops from its widest opening will overcome most of the aberrations introduced by the diopter lens. Higher quality images may be produced, even at wide lens apertures, by employing multi-element plus diopter lenses which are more highly corrected. Century Precision Cine Optics can supply high-grade achromatic plus diopter lenses in both full-field and split-field types, for use with zoom lenses. Leitz also makes achromatic diopter lenses, called ELPROS, in Series 6 and 7.

Very low power plus diopter lenses are useful for close focusing with moderate focal length telephoto lenses which generally cannot be focused closer than 3 or 4 meters (roughly 10 to 13 feet). A telephoto equipped with a diopter lens of +1/4, +1/2 or +3/4 power, will extend the sharp focusing range as close as 1.33 meters (about 4½ feet). Such close focusing distances permits shooting small areas from a practical working distance that leaves room for setting up lights between subject and camera, and also makes panning easier without need for follow-focusing. An ant colony set up behind a plate glass, for example, could be followed about as the ants race through exposed tunnels and go about their work. Such scenes would be very difficult, if not impossible, to film at very close distances with high power plus diopters.

The power of a plus diopter lens is the same regardless of the focal length of the camera lens. Subject magnification depends, as in conventional filming, upon the focal length of the camera lens and the distance from the subject. The plus diopter simply makes it possible to focus sharply at very close distances! A moderate focal length telephoto, or a zoom lens positioned at a similar focal length, will be easiest to work with and will deliver the same size image as a shorter focal length lens positioned closer to the subject. A longer focal length lens produces better perspective, less distortion, and is easier to pan, tilt and zoom on a moving subject. Cross-screen movement may be lined up so that it remains more-or-less equidistant from the lens, particularly if it may be composed in a semi-circle, so it will not require extensive follow-focusing to keep the image sharp.

Depth-of-field is identical at the same *magnification* (image size) and same f/stop for any focal length lens. A camera equipped with a zoom lens, for example may be positioned 10 inches from the subject and the lens adjusted for 50mm focal length and f/4. It will deliver the same size image and same depth-of-field if moved back to 20 inches and set at 100mm and f/4. However, a better quality image will be produced at the longer focal length and greater distance because a lower power plus diopter lens may be used.

Front element focusing, such as employed on zoom lenses, enlarges or reduces the image size as focus is altered from one distance to another. This optical effect is generally unnoticed at normal camera-to-subject distances because it is very slight. However, it is highly magnified at ultra-close distances, so follow-focusing with plus diopter lenses will produce a zoom effect of its own! Focus changes and zooming should be carefully synchronized, or performed as separate actions so that they do not "fight" each other. The expanding or contracting image resulting from follow-focusing may oppose the zoom effect.

Plus diopter lenses do not require an increase in exposure.

## SPLIT-FIELD PLUS DIOPTER LENSES

Split-field plus diopter lenses are *partial lenses* — either cut in half *or* round lenses with one-half a clear optical flat with no power and the remaining half with the power indicated. They may be compared with bi-focal eyeglasses, with the additional advantage that they may be focused on *both* near and far subjects *simultaneously,* rather than on one distance at a time.

Since split-field diopters cover only one-half of the camera lens they set up *two distinct focusing ranges:* a *near* range imaged through the diopter portion of the lens and a *far* range imaged through the conventional lens. Cleverly positioned subjects will *appear* to possess fantastic depth-of-field extending from a few inches to infinity! The diopter portion of the lens may be turned to cover any portion of the frame: top or bottom or either side or even a diagonal area from corner to corner. Very close subject matter, such as an extreme close-up of a player's face, may be sharply focused on one side of the frame through the diopter — and a far distant player sharply focused through the conventional lens. Or, a large close-up of a flower may fill the bottom of the frame and a distant mountain appear sharply focused on top. Panavision's wide-screen format permits using two split-diopters, of similar or different power, on *either* side of the frame. Two players may thus carry on a conversation while facing each other in profile on *either side* of the frame, while a third player may be sharply imaged in the background *inbetween* through the conventional lens. The

many compositional possibilities are limited only by the cinematographer's imagination and the time allowed to set up the shot.

Since each portion of the picture will possess its own distinct depth-of-field it is necessary to cleverly position near and far subjects if an inbetween out-of-focus area is to be avoided. A standing player presents no problem if a tight head shot is made and the distance to the far player is empty air! However, subject matter just beyond the near player will be out-of-focus if it appears in the frame. It is best, therefore, to isolate the foreground image and eliminate anything between it and the background subject — unless a special effect is desired. Split-field filming is not tied down to static fixed set-up in which the near and far subject matter is anchored in position! The camera and/or the player may move and the split-field lens may be slipped into or out of the matte box as the scene progresses to match player or subject movement, or to create in- or out-of-focus effects. Such effects are particularly interesting in television commercials where the product appears in the foreground or is introduced or removed during the scene. The camera may pan on a sharp distant scene and the positioned product slide into the frame in the foreground — in sync with a split-diopter being introduced to hold both images sharp!

Split-field diopters require very careful ground glass focusing at the *shooting aperture* — not wide open. Closing the lens diaphragm after the images are lined up and focused may cause the edge of the diopter to shift across the frame. The trick in lining up the diopter is to "lose" the out-of-focus line in a normal compositional line, such as the corner of a room, the edge of a wall or a column. Or, the scene may be lighted so that the line is lost in a shadowed or dark area, or "burned out" in a "hot" area.

Split-field diopters may be used with zoom lenses, but difficulty may be encountered when zooming because the edge of the lens may tend to "float" from side to side, when the lens is positioned vertically. Zoom shots are possible, however, if time is taken to set up, compose and light the scene so that the demarcation line is properly positioned and moves within tolerable limits.

## WORLD-WIDE ELECTRICAL DATA

ELECTRIC CURRENT ABROAD (Pamphlet No. 295-507), published by the U.S. Department of Commerce, for U.S. electrical manufacturers and exporters, and for U.S. citizens who travel abroad, lists characteristics of electric current (type, number of phases, frequency and voltage) found in major foreign cities throughout the world. A copy may be obtained for 50 cents from:

Superintendent of Documents
U. S. Government Printing Office
Washington, D. C. 20402

## COLOR BALANCE

When a light source is composed of approximately *equal* proportions of *red, blue* and *green,* it is said to be in *neutral balance*. The eye perceives such illumination as *colorless* or "white light." Light appears colored *only* when a *portion of the spectrum* is partially or totally *subtracted*. This occurs with natural light when the atmosphere filters out the yellow rays of the sun on a cloudy or overcast day, or the blue rays at sunset. The human eye and brain, through adaptation and experience, regards most light sources as *white* unless they are obviously colored. Thus a sheet of white paper *appears* white in daylight or under artificial light. However, it is truly white only in direct sunlight, or under simulated sunlight conditions. It is actually *bluish* under overcast daylight because a portion of the red end of the spectrum is missing, and it is *yellowish* when illuminated by tungsten light, which is deficient in blue rays.

Cine color film can make no such color adaptation. It records the scene with a *neutral color balance* only when a good *color match* exists between the *color sensitivity of the color film* and the *spectral energy distribution* (SED) of the light source used for exposure. The red, blue and green emulsion layers of the color film must each record the red, blue and green portions of the light spectrum in proper proportion for a correct color reproduction of the scene. Thus a color film balanced for a particular light source, whether bluish daylight or yellowish tungsten light, can reproduce the scene with a neutral, or white light balance, because each color layer of the film *matches* that respective area of the lighting spectrum. A true gray card exposed under matched film/light spectral conditions will appear neutral. If the card appears bluish the light is deficient in red rays, if it is yellowish it is deficient in blue rays.

When the color balance of the light source does *not* match the color sensitivity of the film it may be *corrected* with a color filter that *subtracts* that portion of the spectrum which *colors the picture*. Daylight color film, for example, is balanced for the overabundance of blue that normally exists outdoors during daylight hours. Tungsten emulsions, on the other hand, are balanced for yellowish tungsten light that is deficient in blue. It is possible however, to *convert* the tungsten film to a daylight color balance by positioning an orange, or amber colored, filter (Kodak 85 or 85B or its equivalent) over the camera lens to *filter* out daylight's *excess blue rays*. The spectral energy distribution (or SED) of the light source will then approximately match that of the yellowish balanced tungsten color film. This results in a neutral balance and reproduces the scene as if the light were colorless. Correcting or converting the light may also be accomplished by filtering the

light source, such as a window, or a spotlight, by positioning the proper color filters in the light path. The color film may also be color corrected when it is printed. Lab corrections are limited, because the dynamic range of luminance levels in a scene is often as wide as the dynamic range of the color film emulsion.

It is not always desirable that the film/light color balance be perfectly matched. Color may be *introduced* into the scene by the cinematographer to create mood, atmosphere, climate, seasonal, location, or other pictorial effects. Or, the lab may "color" the scene by actually filtering the film so that it is out of neutral color balance. A typical example is the theatrical bluish effect used for night scenes. The color effect may thus be accomplished in any of these ways or in combination with both lab and cameraman contributing a portion of the final color effect. The director of photography may position colored gelatins in front of the artificial light sources, or he may position color filters in front of the camera lens to color a portion or all of the scene as desired. These light source and camera filtering effects may be employed in combination to produce yellowish candlelight, reddish firelight, or to add to the yellowish warmth of desert scenes or bluishness of ice and snow scenes. The tropics, the arctic, various seasons, weather changes, time of day changes, sea, mountain or other location appearances may all be given additional pictorial interest and made more realistic by *emphasizing* their particular colored "look." Audiences become more involved with the story when such additional color information is provided that enhances the setting, season, climate, location or weather conditions.

To properly expose color film with a neutral color balance *or* to "color" the scene for out-of-balance color effects it is necessary to understand how the color of a light source is measured. One method of evaluation is by *color temperature* — a measure which defines color of a light source by reference to the *visual* appearance of the light emitted by an ideal radiator, or *black body,* heated to incandescence. A black body is a theoretically perfect thermal radiator because it reflects no light. It emits light only when subjected to heat. When the color of the light source is approximately the same as that of the black body heated to a given temperature, *that* temperature is defined as the color temperature of the light source in *Kelvin* (K). (Note: Lord Kelvin was a British physicist who was the first to experiment with color measurement. The Kelvin scale starts at *absolute zero:* — 273.15° Celsius or zero degrees Kelvin. Color temperature is no longer refered to as so-many *degrees* Kelvin or °K. The unit is now called the *Kelvin,* color temperatures are so-many Kelvin or so-many K.)

As a black body is heated its color changes from deep red, to red, orange, yellow and white. If heated to greater temperature

it turns blue. An important characteristic of a black body light source which is particularly important in color filming, is that the relative amount of radiant energy emitted changes *gradually* from wavelength to wavelength. Such a light source is said to possess a continuous spectrum or a *smoothly varying spectral emission curve*. This gradual change in the color of a black body as the temperature rises and lowers makes it possible to rate its color temperature. Not all light sources follow black body measurements, so color temperature of many are only an approximation based on the *visual appearance* of the light source *compared* to that of a black body at a given temperature.

Kelvin color temperature is based on the *blue*/red ratio of the light source. The *higher* the color temperature, the *bluer* the light. The *lower* the color temperature, the *redder* (or more yellowish or yellow-orange) the light. Think of daylight being higher in color temperature than tungsten light and therefore bluer or cooler. While on the other hand, artificial light sources, other than those that *simulate daylight,* are yellower or warmer. However, so-called daylight-type light sources, such as daylight fluorescent lamps, xenon lamps and arc lights may resemble daylight color quality *visually,* but they have a different spectral balance and color photographic reproduction under such light sources may appear markedly different from similar scenes filmed in actual daylight. This is why it is extremely difficult to perfectly color match outdoor long shots with simulated sunlight studio close-ups.

Color photographic use of Kelvin color temperatures should be applied *only* to tungsten filament lamps and tungsten-halogen or so-called *quartz* lamps. The energy distribution of the light from tungsten lamps depends almost entirely on the temperature of the filament. Although the hot tungsten filament does not radiate exactly according to the laws of a theoretical black body, the radiation is due to the fact that the wire is hot so the energy distribution is nearly identical with that of a somewhat cooler black body. Therefore, for all practical color photographic purposes tungsten lamps may be rated in accordance with black body or Kelvin units.

Sunlight's energy distribution in outer space approximates closely that of a black body at 6565 K. In passing through the earth's atmosphere, however, a considerable amount of light is lost, particularly in the short-wave length region so that when sunlight reaches earth it can no longer be represented by a true black body radiation curve. Sun angle, sun direction, atmospheric conditions, etc., also influence its energy distribution markedly. Technically speaking, therefore, Kelvin temperatures assigned to sunlight and/or daylight are only a *visual* approximation of a black body at any particular color temperature. However, for practical photographic purposes Kelvin ratings may be considered

as *visual color temperature* or *film balance color temperature.*

Arc lights, fluorescent lamps, mercury lamps, xenon lamps, and other artificial light sources that do *not* employ a tungsten filament cannot be accurately defined by color temperature. When Kelvin temperature is applied to such non-black body light sources it does not describe the spectral quality of the light. It only implies that the light has a *visual appearance* of a black body at that color temperature. An evaluation of daylight, for example, should be based not only on the blue/red but also the green/red ratios, so that the spectral balance of the light may be accurately described. The visual color of sunlight shortly after sunrise or at sunset, when it is close to the horizon, may approximate that of a tungsten filament lamp, but its spectral energy distribution (SED) will be markedly different.

Fluorescent and other gaseous discharge lamps do *not* possess a continuous spectrum. Their light may *not* be properly evaluated in terms of Kelvin temperature. (See: FLUORESCENT LIGHT)

Although Kelvin color temperature is loosely applied to all natural and artificial light sources, the experienced cinematographer should realize that it applies *only* to *tungsten filament lamps*. Such understanding will prevent recording peculiar color effects, or explaining what happened when a scene was filmed under other than tungsten lighting and filter correction was made on the basis of Kelvin temperature.

The blue/red ratio of true *black body* light sources, such as tungsten lamps, may be evaluated with a *two-color* temperature meter. However, the spectral energy distribution (SED) of *non-black body* light sources, such as natural light and gaseous discharge lamps with discontinuous spectrums, should be measured with a three-color meter, such as the SPECTRA FILM/LENS BALANCE THREE-COLOR meter, or the MINOLTA THREE-COLOR METER. These meters evaluate not only the blue/red ratio but also the green/red ratio and take into account the spectral sensitivity of professional color cine film. The SPECTRA meter, takes typical professional cine lenses into consideration also. Even the finest three-color meter, however, may not produce perfect color results in all cases because of the disparity in spectral sensitivities of different types of color film.

A color meter is not necessarily required if the spectral balance of the light source is known. This situation occurs outdoors when filming in average daylight, on overcast days, or in the shade, or at sunset, etc. (Note: The various MIRED NOMOGRAMS may be employed for finding the particular color filter required to correct known light conditions.) It occurs indoors when proper color temperature tungsten or tungsten-halogen lamps are used at their *rated voltage*. If a system-type color film is used an approximate

light/film color match is sufficient because the final color correction may be made by the lab when the film is printed.

Color temperature of tungsten or tungsten-halogen lamps will vary with their applied voltage. All voltage readings should be taken at the light source, not back at the electrical tie-in box or generator which may be located at a great distance. Significant voltage drop can occur over long extension cables. One volt equals ten Kelvin, so a ten volt drop would result in lowering the Kelvin temperature 100 K. This would be a significant drop that would produce reddish flesh tones. A good voltage meter, such as the Weston 150/75 volt model 433-1903008 voltmeter, which is accurate within 1% and responds to the r.m.s. voltage, may be used for evaluating tungsten illumination. Commonly used multi-meter and volt-ohm meters are not very accurate and often lose what little accuracy they possess through rough usage. They should not be relied upon to determine applied lamp voltage.

Best color results are achieved when proper color temperature lamps are used at their rated voltage. Voltage variations may be corrected in the camera by positioning light balancing filters in front of the lens, thus in effect subtracting excess red from the light when voltage is low, by using the proper bluish filter — or subtracting excess blue, when the voltage is high, by using the proper yellowish filter. There is no need to filter correct small variations in voltage when shooting with a system color film that can be color corrected by the lab. It is better to correct the voltage whenever possible, rather than filter the film. Correct color reproduction under studio conditions demands not only precise voltage control but *constant* voltage. Variations in voltage can cause dificult problems when scenes are inter-cut. The lab may have difficulty matching color correction on such scenes if wide variations in voltage occur throughout a sequence. A constant voltage transformer should be installed for filming small set-ups, such as time-lapse or animation scenes that are filmed a frame at a time over a long period, or the scenes may flicker from voltage variations.

Location interior filming may introduce problems, such as low voltage, or voltage fluctuations during a scene, or from scene to scene as filming progresses. The local power company should be consulted if extensive photography is required on remote sites. They can generally arrange a special electrical tie-in on a temporary basis for a nominal service charge. Voltage fluctuations may occur at twilight when the power station is adjusting the load from commercial to domestic use, to accommodate the additional power required by home owners turning on lights, appliances and television sets. This is an excellent time to call a dinner break if filming is to continue into the evening hours.

## MIRED VALUES

The color temperature of a light source may also be expressed in *mired values*. The mired (*mi*cro-*re*ciprocal *d*egrees) value of a light source is the color temperature in Kelvin divided into 1,000,000. For example, a tungsten lamp with a color temperature of 3200 K has a mired value of 312. (1,000,000 ÷ 3200 = 312) If the lamp is operated at a lowered voltage, such as 105 volts instead of its rated 115 volts, it will have a color temperature of 3100 K, or a mired value of 322. Daylight and tungsten light conditions may thus be given a mired value that represents its Kelvin temperature. Color films may be given a mired value that defines their light balance. A color film balanced for 3200 K would have a mired value of 312, the same as a tungsten lamp of that color temperature.

Color filters may also be given a mired value. Light conversion, light correction and light balancing filters all have the power to *shift* the color temperature, and therefore the mired value, by a definite amount. Each filter may be assigned a *mired shift value* by *subtracting* the color temperature of the *light through the filter* from the color temperature of the *original light source*. The value will be either negative (−) or positive (+), depending on the color of the filter. *Bluish* filters, which *raise* (cool) the color temperature have a *negative* mired shift value. *Yellowish* filters, which *lower* (warm) the color temperature have a positive mired shift value.

When the mired value of the color film and the light condition match no filter correction is required. When the mired value of the color film and the light condition do *not* match, a color filter with the mired shift value equal to the *difference* between film and light source may be employed for correction. The filter will be *bluish* (−) if the temperature of the light is *lower* than that of the film balance because the warmer light source must be *cooled* (raised) to match the color balance of the film. The filter will be *yellowish* (+) if the temperature of the light source is *higher* than that of the film balance because the cooler light source must be *warmed* (lowered) to match the color balance of the flim. For example, an *amber* (+ warm) filter with a mired value of approximately +130 is required to lower average 5500 K (182) photographic daylight to match the mired value of 3200 K (312) tungsten balanced color film. (312 − 182 = 130) The Kodak Daylight Conversion Filter No. 85B, with a mired value of +131, meets this requirement.

Filters can be combined by adding their mired shift values with due regard to the sign. Use of multiple filters, however, may

cause considerable reflection loss, due to the number of surfaces involved. Such losses can be partly eliminated by cementing the filters together in pairs.

The mired values of all Eastman, Harrison and Agfa-Gevaert color filters are listed in their respective tables. Mired values of color temperatures from 2000 to 10,000 K are also listed for quick reference.

The filter required for correcting any light source to either tungsten color balanced film (3200 K or 3400 K) or daylight color balanced film may be quickly selected by employing a MIRED NOMOGRAM FOR LIGHT SOURCE CONVERSION. Select the desired KODAK, HARRISON or AGFA-GEVAERT nomogram on one of the following pages to find the filter required for correcting any light source between 2000 K and 10,000 K to any color film balance. (NOTE: A blank nomogram is also provided for writing in a personal set of filters or filters locally available. Write the number of the filter alongside its mired number on the center column. If the filter's mired shift value is unknown but its use is known, the value may be easily computed. For example, a filter that corrects ordinary household incandescent light of approximately 2800 K to 3200 K tungsten color balance would be figured thus: 312 (the value for 3200 K) subtracted from 357 (the value for 2800 K) = 45. The filter would be minus (−) because it is *bluish,* in order to raise or cool the lower color temperature light source to that of the higher color balanced film.)

The mired nomogram is easy to use. The left column lists the color temperature of the original light source. Easily identified natural and artificial light conditions and commonly employed lamps and filters are listed alongside their respective color temperatures. Color correction with known light sources is thus easily accomplished without a color meter. However, if the spectral energy distribution of the light source is important it will be necessary to employ a three-color meter to properly evaluate the red, green and blue portions of the spectrum.

The center column displays the color filters alongside their mired shift values.

The right column lists the color temperature of the light *through the filter,* that is the *converted light source* — the light used to expose the color film.

To find the mired shift value, and the particular filter required, for a particular correction or conversion, place the HARRISON clear plastic ruler on the points corresponding to the color temperature of the original light source and the color temperature of the desired source — which is the color balance of the film being used to shoot the scene. The point where the ruler crosses the center column indicates the filter required. (This may be easily

seen *through* the clear plastic ruler.) The zero point on the center column indicates that no filter is required. Above the zero requires yellowish (+) filters and below the zero requires bluish (−) filters.

The nomogram makes it easy to visualize what happens when the light is higher or lower than the film's color balance. It may be desirable to create a color effect, such as candlelight, so the film may be exposed with yellowish light, or yellow gels on the lights, or the lights may be dimmed to a lower color temperature for a warm effect. Or, a filter may be chosen for a warmer or cooler effect than normal to warm up a desert scene or cool a snow scene. This is easily accomplished by simply choosing a filter that provides less correction than required for correct color temperature — to produce warmer results; and a filter with greater correction to produce cooler results.

The nomogram works only with light sources whose spectral radiation characteristics are not markedly different from those of an ideal black body. It will work perfectly with tungsten lamps and it will generally prove practical for daylight and arc light. It will not work with fluorescent and similar gaseous discharge lamps. This is the reason that filters for correcting fluorescent light are not included in the nomogram. They are treated in a separate text and tables, with recommendations for their use.

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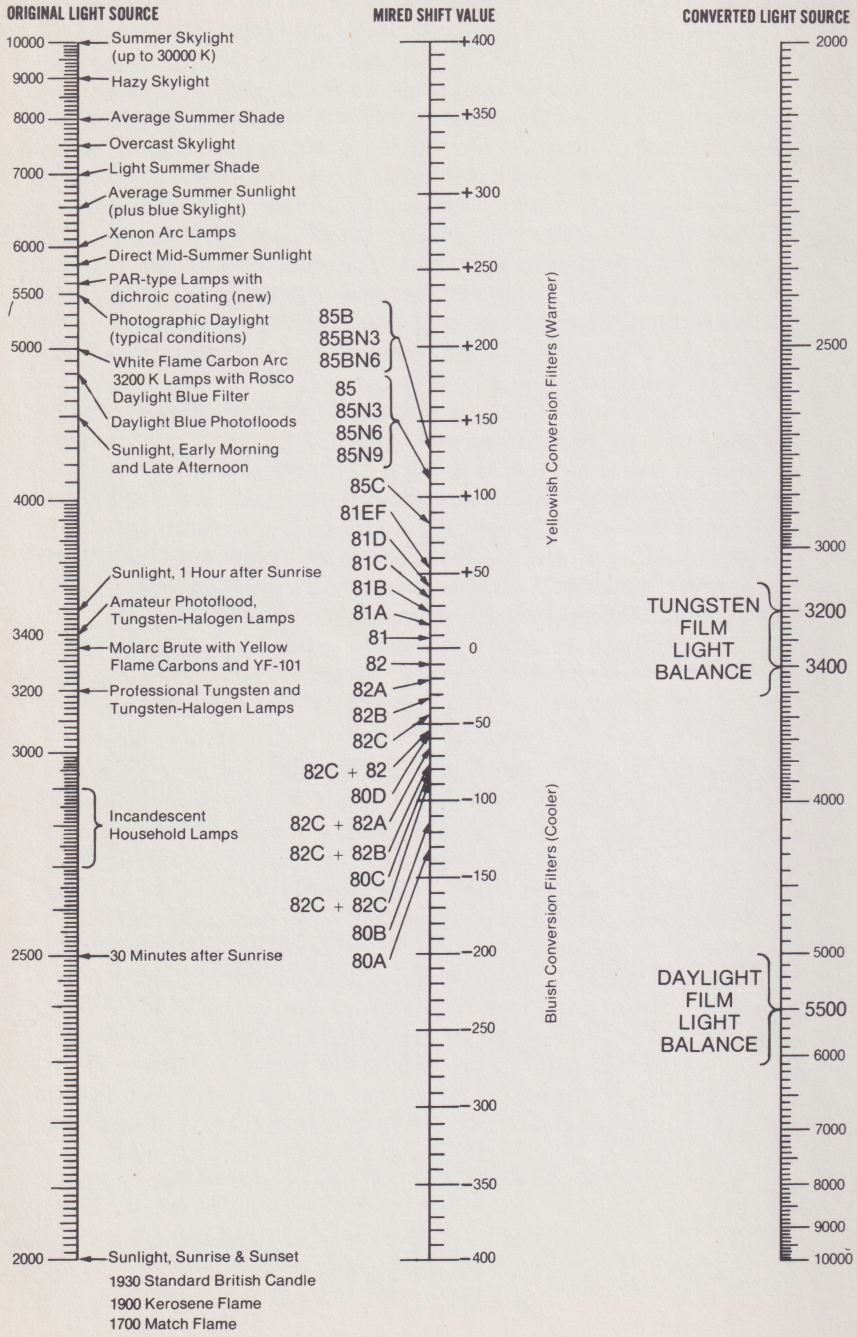
## CINE

CINE: COUNCIL ON INTERNATIONAL NONTHEATRICAL EVENTS was set up in 1957 as a voluntary, nonprofit organization representing a cross-section of nontheatrical film and television leaders: producers, sponsors, distributors, manufacturers, users, and associations. CINE selects nontheatrical films, television documentaries, and theatrical short subjects each year for United States representation in more than 100 international film festivals. There is no limit on subject matter. Films are first judged by 30 regional juries and then the winners are sent to semi-final juries — and those surviving are sent to Washington, D. C., where national judges select the finals. As many as 200 films have been chosen to represent the United States abroad during a single year. A GOLDEN EAGLE certificate is awarded to each professional film chosen, and a CINE EAGLE to adult amateur and youth films. For application forms and further information write:

CINE
1210 16th Street, N.W.
Washington, D. C. 20036

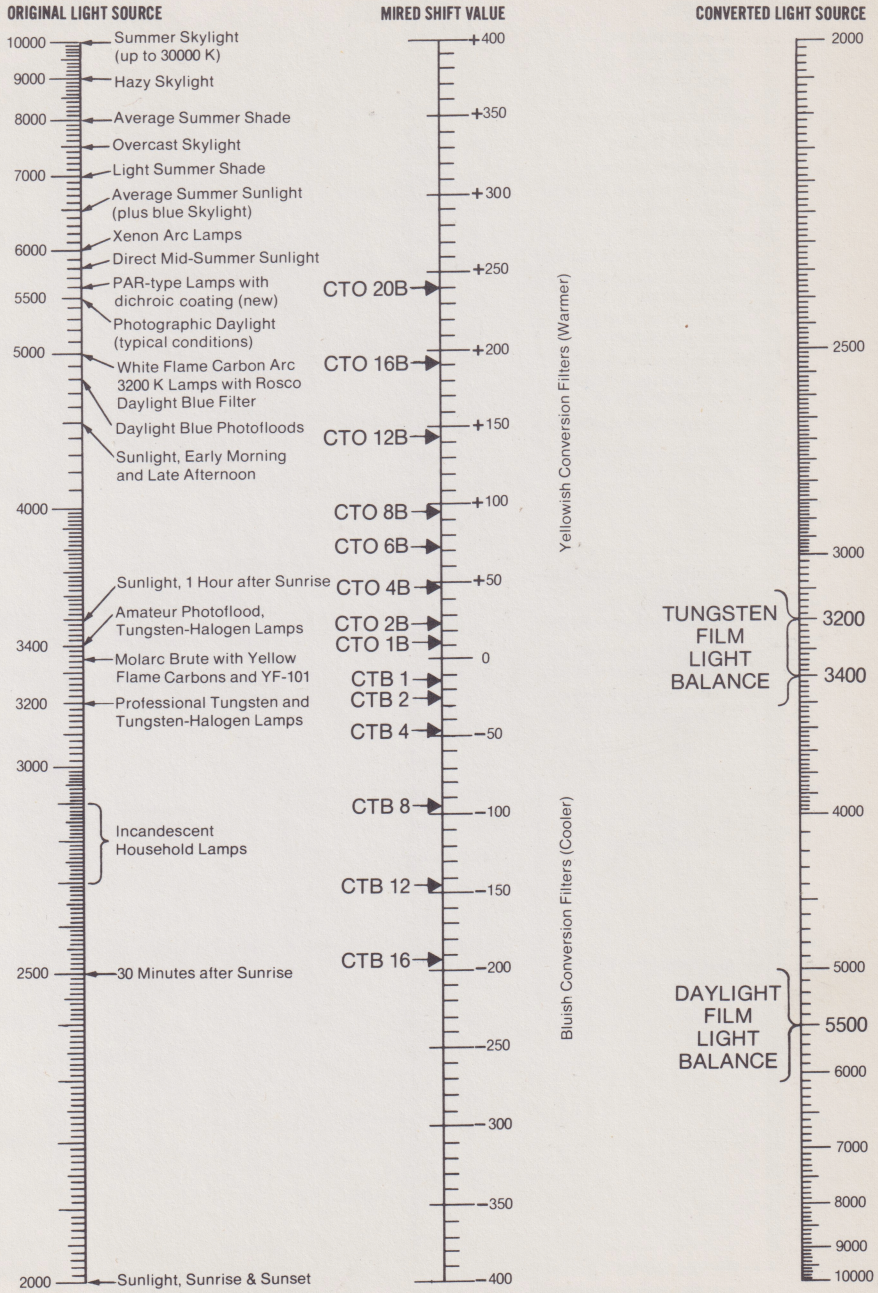
# MIRED NOMOGRAM FOR LIGHT SOURCE CONVERSION

## EASTMAN KODAK FILTERS



# MIRED NOMOGRAM FOR LIGHT SOURCE CONVERSION

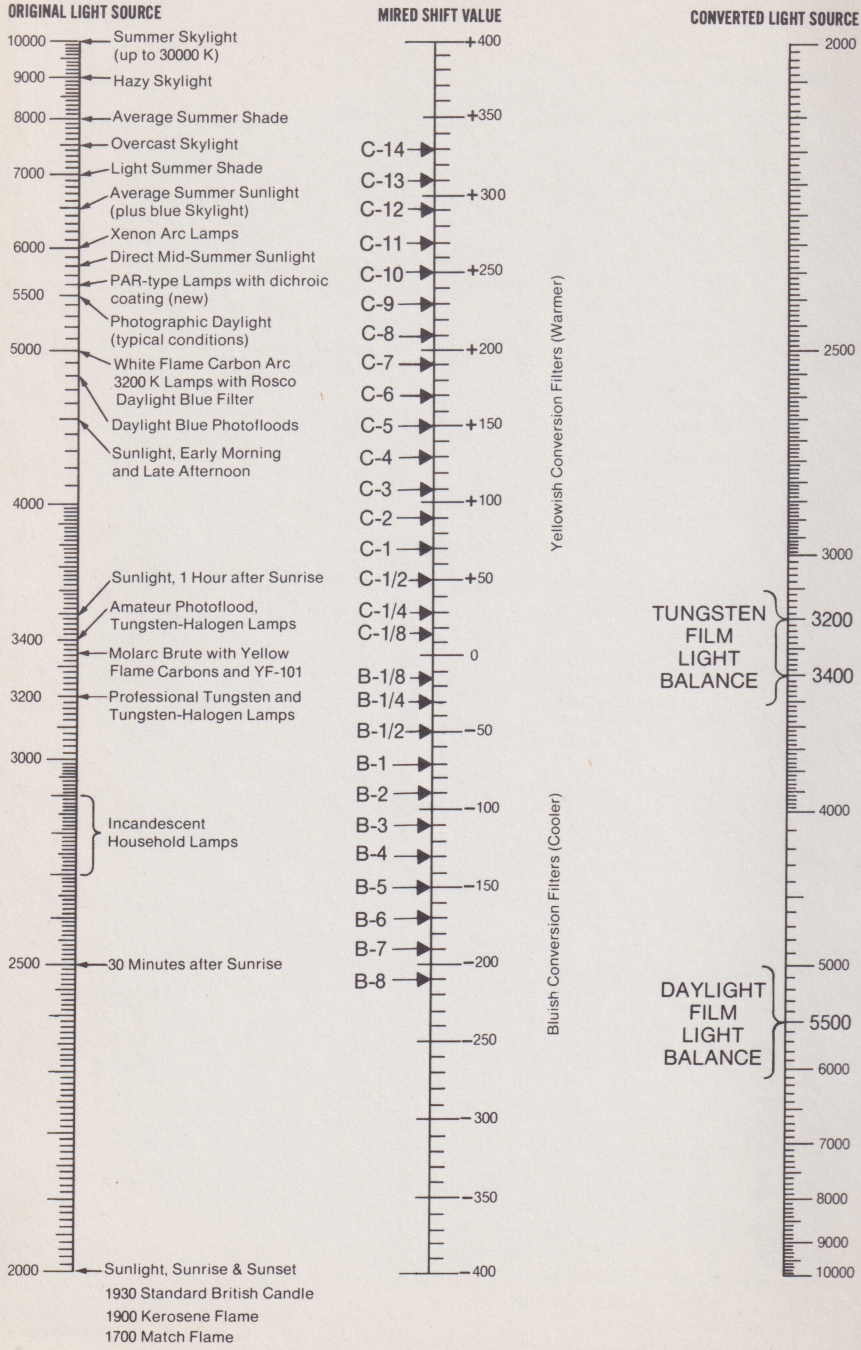
## AGFA-GEVAERT COLOR TEMPERATURE FILTERS




*NOTE: Agfa-Gevaert daylight color films (and tungsten balanced color films converted to daylight) are balanced for 6000 K or 166 mired.*

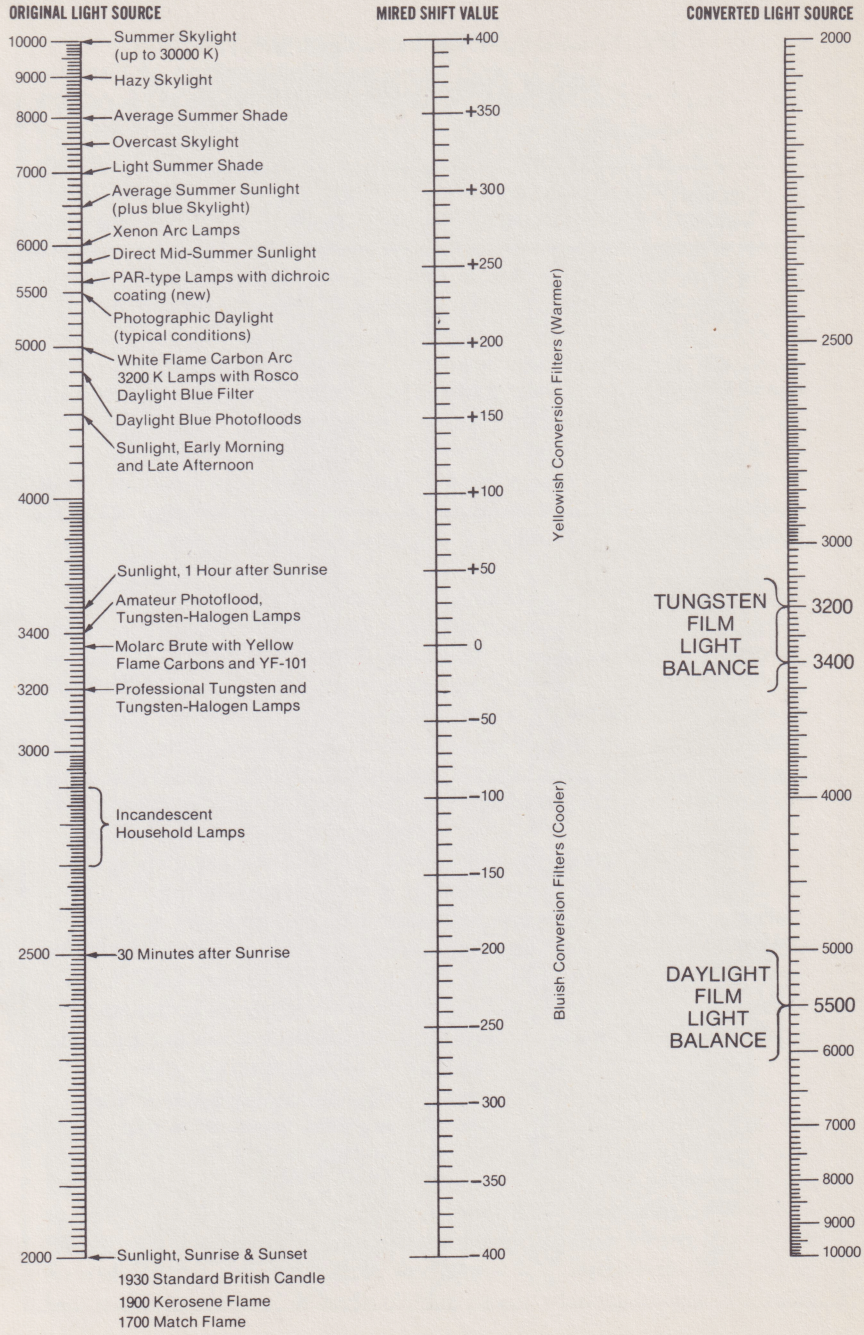
# MIRED NOMOGRAM FOR LIGHT SOURCE CONVERSION

## HARRISON & HARRISON LIGHT CORRECTOR SERIES



# MIRED NOMOGRAM FOR LIGHT SOURCE CONVERSION

## (WRITE IN YOUR OWN CT FILTER SERIES)



## MIRED VALUES OF COLOR TEMPERATURES FROM 2000-10,000 KELVIN

| KELVIN TEMP. | MIRED VALUE | KELVIN TEMP. | MIRED VALUE |
|---|---|---|---|
| 2000 | 500 | 6000 | 167 |
| 2100 | 476 | 6100 | 164 |
| 2200 | 455 | 6200 | 161 |
| 2300 | 435 | 6300 | 159 |
| 2400 | 417 | 6400 | 156 |
| 2500 | 400 | 6500 | 154 |
| 2600 | 385 | 6600 | 152 |
| 2700 | 370 | 6700 | 149 |
| 2800 | 357 | 6800 | 147 |
| 2900 | 345 | 6900 | 145 |
| 3000 | 333 | 7000 | 143 |
| 3100 | 323 | 7100 | 140 |
| 3200 | 312 | 7200 | 139 |
| 3300 | 303 | 7300 | 137 |
| 3400 | 294 | 7800 | 128 |
| 3500 | 286 | 7900 | 126 |
| 3600 | 278 | 8000 | 125 |
| 3700 | 270 | 8100 | 123 |
| 3800 | 263 | 8200 | 122 |
| 3900 | 256 | 8300 | 120 |
| 4000 | 250 | 8400 | 119 |
| 4100 | 244 | 8500 | 118 |
| 4200 | 238 | 8600 | 116 |
| 4300 | 233 | 8700 | 115 |
| 4400 | 227 | 8800 | 114 |
| 4500 | 222 | 8900 | 112 |
| 4600 | 217 | 9000 | 111 |
| 4700 | 213 | 10,000 | 100 |
| 4800 | 208 | | |
| 4900 | 204 | | |
| 5000 | 200 | | |
| 5100 | 196 | | |
| 5200 | 192 | | |
| 5300 | 189 | | |
| 5400 | 185 | | |
| 5500 | 182 | | |
| 5600 | 179 | | |
| 5700 | 175 | | |
| 5800 | 172 | | |
| 5900 | 169 | | |

Subtract Mired Value of existing light source from that of a converted light source (or film color balance) to find Mired Shift Value of filter required. Warm shift requires plus filter, cool shift minus filter.

## FILTERS

Glass or gelatin filters — round, rectangular or square — may be inserted in a cine camera matte box positioned in front of the lens. Round glass filters may be mounted directly on the front of the lens by employing a filter retaining ring, or a lens hood with provision for mounting a filter. Gelatin filters may be mounted behind the lens, either in a filter slot cut into the camera body in front of the film aperture, or directly on the rear of the lens barrel. Filter kits for lens rear mounting are available for most popular zoom lenses. They consist of a die cutter, filter holders that slip on the back of the lens barrel, tweezers and a storage file for extra gels.

Choice of glass or gelatin, in front of or behind the lens involves several considerations. Only the more common filters are available in glass in all sizes; it is often impractical to employ a matte box, particularly with a zoom or long telephoto lens; more than one filter may be required; or color and/or neutral density filters may be combined with diffusion and/or special effects filters. It may be necessary, therefore, to employ *both* glass and gelatin, and *both* front and rear mounting to handle all of the filter requirements for a particular shot.

First preference for zoom lenses and conventional lenses, up to moderate focal length telephotos, is a top quality lens bench tested or photographically tested optically flat glass filter. However, glass filters are generally impractical for extreme wide-angle or very long telephoto lenses because of the extremely large diameter filter required. Such glass filters are relatively expensive in large sizes and often difficult to find, but cheap filters are false economy. The quality of the image produced by the finest lens may be impaired by a poor quality glass filter.

Gelatin filters are second choice but generally the only choice for large diameter lenses. It is impractical to mount gelatin filters in front of the lens because dust, dirt and the elements materially affect their use. In an emergency they may be placed in a gelatin filter holder and positioned in a matte box, or in a filter retainer ring mounted directly on the lens — but they should be checked often to be certain they remain clean. Gelatin filters, therefore, are generally mounted behind the lens.

Behind the lens gelatin filters are optically efficient, inexpensive, easy to mount, small in diameter, and protected from the elements. However, a behind-the-lens gelatin filter *displaces* the focal point of the lens by approximately one-third of its thickness (0.0015″). Although such displacement may not seriously impair image quality with moderate focal length lenses which are reflex focused, it may cause loss of sharpness with extremely short focal length lenses and with zoom lenses, particularly a zoom lens with

a relatively short wide-angle focal length. It is advisable, therefore, to use no more than a *single thickness* of gelatin behind the lens because the displacement will increase proportionately with additional gels and they will also contribute additional glare.

The best solution for employing behind-the-lens gelatin filters is to have the lens collimated with a gelatin filter in position. It will then be necessary to use a dummy colorless (Wratten Filter No. 0), or an ultraviolet gelatin filter, which has no factor, whenever a filter is *not* required. Since many professional cine cameras are equipped solely with a zoom lens, or a zoom and an extreme wide-angle lens, it is a simple matter to collimate the lens(es) for behind-the-lens gelatin filters to insure optimum image sharpness regardless of focal length, and for utmost convenience whether shooting with a color gelatin or a clear gelatin.

A few extreme wide-angle lenses solve the filter problem with a *between-the-lens-elements* filter slot which allows use of gelatin filters without affecting image sharpness. Most reflex-focusing cine cameras have less than 15X magnification so it is very difficult, if not impossible, to accurately focus wide-angle lenses. It is a fallacy to believe that because wide-angle lenses have great *depth-of-field* in the *subject area* that careful focusing and accurate lens seating are not required. Actually, the opposite is true: *depth-of-focus* at the *film plane* is most critical with wide-angle lenses and image displacement — through use of gelatin filters, improper lens seating or wrong lens flange to film plane distance — will result in unsharp images. Wide-angle and extreme wide-angle lenses are preferably focused by a range finder or measuring tape — or even by *guessing the distance,* rather than trying to focus the lens by eye on a reflex viewfinder groundglass. This assumes, of course, that the lens is properly collimated for the camera and the focusing scale is correct. Lens collimation, therefore, is much more critical for extremely short focal length lenses and for zoom lenses, than it is for telephoto lenses.

A behind-the-lens gelatin filter should be checked during filming for cleanliness. It may pick up surface dust or the camera shutter may throw oil which will spot the filter surface and produce dark circles on the picture. Dust or oil will be more apparent on the picture the closer the filter is positioned to the film plane. Care should be taken when inserting a gelatin filter holder in a camera filter slot to make certain the gelatin does not slip out of position. This will result in partial filtering because the gelatin does not cover the entire film area. Remove the lens or turn the lens turret to an empty lens socket so that the filter may be checked after it is inserted. It is a good idea to write the filter number on a small piece of masking tape and stick it to the side of the camera or on the lens barrel — as a constant reminder that

an *inside filter* is in position. Many interior scenes have been ruined because a Daylight No. 85 gelatin was not pulled when the camera crew moved indoors!

It is not advisable to combine glass and gelatin filters together, or to stack two or more gelatin filters in a "filter sandwich." Such sandwiching may produce Newton rings: concentric bands of colored light around areas where two transparent surfaces are not quite in contact. Newton rings may result in alternate light and dark bands of colored light on the picture. Use a combined filter whenever available, such as the 85N3, rather than an 85 and an ND 0.3. There are times, of course, when several filters are required, such as correcting fluorescent illumination, or employing color filters and special effects fog, star or diffusion filters. If two filters are required mount a top quality glass filter in front and a gelatin filter behind, preferably with a lens collimated for use with a gelatin.

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## ROSCO LIGHT CONTROL MEDIA FOR ARTIFICIAL LIGHTS OR WINDOWS

ROSCO LABORATORIES manufacture a full range of cinematic light control media designed to fit the very special and diverse needs of lighting for color cinematography. CINEGELS control color temperature of artificial lights of all kinds, as well as convert daylight to 3200 K, and reduce its intensity, if desired. Diffusion materials and reflector surfaces are also available to control the "quality" of the light in another dimension.

Various types of CINEGELS are available to gel windows. Some adhere directly to the glass, others require framing. There are special gels to balance daylight and dichroic coated lamps, or conventional 3200 K lamps, to fluorescent illumination.

CINEGELS are available in eight different blues to raise the color temperature of 3200 K light sources. Each has a specific function: from boosting fading blue-faced FAY lamps to replacing dichroics altogether.

Seven different diffusion materials are offered, ranging from a "Tough Frost" able to stand up under high-heat situations — to a "Tough Spun" which produces diffusion equal to spun glass but without the side-effect itch and irritation.

## NEUTRAL DENSITY FILTERS FOR CAMERA LENS OR WINDOWS

Neutral Density Filters are used in color cinematography to reduce the intensity of light reaching the film without affecting the tonal rendition of colors in the original scene. They are used on the camera lens for filming in bright sunlight, particularly with very fast films, to control exposure when the smallest lens aperture is still too large; or when a larger lens aperture is desirable for differential focusing (to eliminate unwanted background or reduce depth-of-field). The most popular ND's are the ND 0.3, ND 0.6 and ND 0.9 (also termed simply N3, N6 and N9) which reduce light intensity 1, 2 and 3 stops respectively. (NOTE: These were formerly referred to as ND .30, .60 and .90.) These popular densities are also available in combination with Wratten Daylight Conversion Filters Number 85 and 85B. A combined filter is preferable to separate color and neutral density filters sandwiched together. The 85 and N3, N6 and N9 are also available, separately or combined, in plastic sheets, rolls and semi-rigid panels for window use, to convert daylight to tungsten light color balance and/or to reduce daylight intensity.

See: ROSCO LIGHT SOURCE FILTERS.

| NEUTRAL DENSITY | PERCENT TRANSMISSION | CINE FACTOR | STOPS INCREASE | COMBINED WITH NO. 85 |
|---|---|---|---|---|
| 0.1 | 80 | 1.3 | 1/3 | |
| 0.2 | 64 | 1.6 | 2/3 | |
| 0.3 | 50 | 2 | 1 | 85N3 |
| 0.4 | 40 | 2.5 | 1 1/3 | |
| 0.5 | 32 | 3.2 | 1 2/3 | |
| 0.6 | 25 | 4 | 2 | 85N6 |
| 0.7 | 20 | 5 | 2 1/3 | |
| 0.8 | 16 | 6 | 2 2/3 | |
| 0.9 | 12 | 8 | 3 | 85N9 |
| 1.0 | 10 | 10 | 3 1/3 | |
| 2.0 | 1 | 100 | 6 2/3 | |
| 3.0 | 0.1 | 1,000 | 10 | |
| 4.0 | 0.01 | 10,000 | 13 1/3 | |

## KODAK CONVERSION FILTERS FOR COLOR FILMS

Conversion filters are intended for use over the camera lens to make *significant* changes in the color temperature of illumination, such as converting daylight to artificial light.

| FILTER COLOR | FILTER NUMBER | CINE FACTOR | EXPOSURE INCREASE IN STOPS* | CONVERSION IN DEGREES K | MIRED SHIFT VALUE |
|---|---|---|---|---|---|
| BLUE | 80A | 4 | 2 | 3200 to 5500 | −131 |
| | 80B | 3.2 | 1 2/3 | 3400 to 5500 | −112 |
| | 80C | 2 | 1 | 3800 to 5500 | − 81 |
| | 80D | 1.25 | 1/3 | 4200 to 5500 | − 56 |
| AMBER | 85C | 1.25 | 1/3 | 5500 to 3800 | + 81 |
| | 85 | 1.6 | 2/3 | 5500 to 3400 | +112 |
| | 85N3 | 3.2 | 1 2/3 | 5500 to 3400 | +112 |
| | 85N6 | 6 | 2 2/3 | 5500 to 3400 | +112 |
| | 85N9 | 12.5 | 3 2/3 | 5500 to 3400 | +112 |
| | 85B | 1.6 | 2/3 | 5500 to 3200 | +131 |
| | 85BN3 | 3.2 | 1 2/3 | 5500 to 3200 | +131 |
| | 85BN6 | 6 | 2 2/3 | 5500 to 3200 | +131 |

NOTE: 85 or 85B when combined with N3, N6 or N9, require only 1, 2, or 3 stops increase, respectively, when Daylight Exposure Index is used for exposing Tungsten Balanced color film in daylight with conversion filter.

The CINE FACTOR may be used with the *Cine Exposure Calculator*, the *Multiple Factor Calculator* and the *Effective Exposure Index Calculator* for adjusting normal exposure.

*These values are approximate. For critical work, they should be checked by practical test, expecially if more than one filter is used.

## KODAK COLOR COMPENSATING FILTERS

Color compensating filters differ from conversion filters in that they control by attenuating principally the red, blue, or green part of the spectrum. While controlling one color, the filter transmits one or both of the other two colors. Thus, color compensating filters are used to make changes in the color balance of pictures recorded on color films, or to compensate for deficiencies in the spectral quality of the light source. Kodak CC Filters can be used singly, or in combination, to introduce almost any desired correction in various phases of color cinematography. Note: exposure increases are approximate. For critical filming they should be checked by practical test, especially if more than one filter is used.

| Yellow (Absorbs Blue) | Exposure Increase In Stops | Magenta (Absorbs Green) | Exposure Increase In Stops | Cyan (Absorbs Red) | Exposure Increase In Stops |
|---|---|---|---|---|---|
| CC-025Y | - | CC-025M | - | CC-025C | - |
| CC-05Y | - | CC-05M | ⅓ | CC-05C | ⅓ |
| CC-10Y | ⅓ | CC-10M | ⅓ | CC-10C | ⅓ |
| CC-20Y | ⅓ | CC-20M | ⅓ | CC-20C | ⅓ |
| CC-30Y | ⅓ | CC-30M | ⅔ | CC-30C | ⅓ |
| CC-40Y | ⅓ | CC-40M | ⅔ | CC-40C | ⅔ |
| CC-50Y | ⅔ | CC-50M | ⅔ | CC-50C | 1 |

| Red (Absorbs Blue and Green) | Exposure Increase In Stops | Green (Absorbs Blue and Red) | Exposure Increase In Stops | Blue (Absorbs Red and Green) | Exposure Increase In Stops |
|---|---|---|---|---|---|
| CC-025R | - | - | - | - | - |
| CC-05R | ⅓ | CC-05G | ⅓ | CC-05B | ⅓ |
| CC-10R | ⅓ | CC-10G | ⅓ | CC-10B | ⅓ |
| CC-20R | ⅓ | CC-20G | ⅓ | CC-20B | ⅔ |
| CC-30R | ⅔ | CC-30G | ⅔ | CC-30B | ⅔ |
| CC-40R | ⅔ | CC-40G | ⅔ | CC-40B | 1 |
| CC-50R | 1 | CC-50G | 1 | CC-50B | 1⅓ |

## KODAK LIGHT BALANCING FILTERS

Light Balancing filters enable the cinematographer to make *minor* adjustments in the color quality of illumination reaching the film in order to obtain *cooler* (bluer) or *warmer* (yellower) color rendering. They are intended for use over the camera lens. Where a color temperature meter is available to determine the color temperature of prevailing light, *or* where the color temperature is already known, the following table can be used to convert the prevailing color temperature to daylight (5500 K) or tungsten (3200 K or 3400 K). The 5500 K column is offered for experimental use only — it is not provided by KODAK. To correct for color temperatures other than those listed below, use the KODAK COLOR FILTER NOMOGRAM.

| FILTER COLOR | FILTER NUMBER | CINE FACTOR | EXPOSURE INCREASE IN STOPS* | TO OBTAIN 5500 K FROM: | TO OBTAIN 3200 K FROM: | TO OBTAIN 3400 K FROM: | MIRED SHIFT VALUE |
|---|---|---|---|---|---|---|---|
| YELLOWISH | 81 | 1.25 | 1/3 | — | 3300 K | 3510 K | + 9 |
| | 81A | 1.25 | 1/3 | 6100 K | 3400 K | 3630 K | +18 |
| | 81B | 1.25 | 1/3 | 6450 K | 3500 K | 3740 K | +27 |
| | 81C | 1.25 | 1/3 | 6800 K | 3600 K | 3850 K | +35 |
| | 81D | 1.6 | 2/3 | 7000 K | 3700 K | 3970 K | +42 |
| | 81EF | 1.6 | 2/3 | 7750 K | 3850 K | 4140 K | +52 |
| NO FILTER REQUIRED WHEN FILM IS BALANCED FOR: | | | | 5500 K | 3200 K | 3400 K | |
| BLUISH | 82C + 82C | 2.5 | 1 1/3 | 3700 K | 2490 K | 2610 K | −89 |
| | 82C + 82B | 2.5 | 1 1/3 | 3850 K | 2570 K | 2700 K | −77 |
| | 82C + 82A | 2 | 1 | 4050 K | 2650 K | 2780 K | −65 |
| | 82C + 82 | 2 | 1 | 4220 K | 2720 K | 2870 K | −55 |
| | 82C | 1.6 | 2/3 | 4400 K | 2800 K | 2950 K | −45 |
| | 82B | 1.6 | 2/3 | 4670 K | 2900 K | 3060 K | −32 |
| | 82A | 1.25 | 1/3 | 4930 K | 3000 K | 3180 K | −21 |
| | 82 | 1.25 | 1/3 | 5210 K | 3100 K | 3290 K | −10 |

*These values are approximate. For critical work they should be checked by practical tests, especially if more than one filter is used.

## HARRISON LIGHT CORRECTOR SERIES

Harrison Light Corrector Series "C" *lower* (warm) the color temperature and *increase* the mired value. Series "B" *raise* (cool) the color temperature and *decrease* the mired value. All filters, except the B-1/8 and C-1/8, raise or lower the value by 20 mireds. The "1/2" filter in either series may be used in combination with any other filter in its respective series to raise or lower the value an additional 10 mireds. Example: C-2 + C-1/2 = +100 mireds.

| FILTER COLOR | FILTER NUMBER | CINE FACTOR | EXPOSURE INCREASE IN STOPS* | MIRED SHIFT VALUE |
|---|---|---|---|---|
| CORAL | C-1/8 | — | — | + 15 |
| | C-1/4 | 1.25 | 1/3 | + 30 |
| | C-1/2 | 1.25 | 1/3 | + 50 |
| | C-1 | 1.25 | 1/3 | + 70 |
| | C-2 | 1.25 | 1/3 | + 90 |
| | C-3 | 1.6 | 2/3 | +110 |
| | C-4 | 1.6 | 2/3 | +130 |
| | C-5 | 1.6 | 2/3 | +150 |
| | C-6 | 1.6 | 2/3 | +170 |
| | C-7 | 2 | 1 | +190 |
| | C-8 | 2 | 1 | +210 |
| | C-9 | 2 | 1 | +230 |
| | C-10 | 2.5 | 1 1/3 | +250 |
| | C-11 | 2.5 | 1 1/3 | +270 |
| | C-12 | 2.5 | 1 1/3 | +290 |
| | C-13 | 3.2 | 1 2/3 | +310 |
| | C-14 | 3.2 | 1 2/3 | +330 |
| BLUE | B-1/8 | — | — | − 15 |
| | B-1/4 | 1.25 | 1/3 | − 30 |
| | B-1/2 | 1.25 | 1/3 | − 50 |
| | B-1 | 1.6 | 2/3 | − 70 |
| | B-2 | 2 | 1 | − 90 |
| | B-3 | 2.5 | 1 1/3 | −110 |
| | B-4 | 3.2 | 1 2/3 | −130 |
| | B-5 | 4 | 2 | −150 |
| | B-6 | 5 | 2 1/3 | −170 |
| | B-7 | 5 | 2 1/3 | −190 |
| | B-8 | 6 | 2 2/3 | −210 |

## AGFA-GEVAERT COLOR TEMPERATURE FILTERS

Agfa-Gevaert *orange* CTO filters *lower* (warm the color temperature (Kelvin values) and *increase* the mired value. *Blue* CTB filters *raise* (cool) the color temperature and *decrease* the mired value. The shift in mired values is determined by multiplying by 12 the number following the letters CTO or CTB. For example, CTO 12B filter produces a mired shift of 12 × 12 = 144 mired (*warming* orange, amber or yellowish filters always have a "plus" value because they increase the mired value).

| FILTER COLOR | FILTER NUMBER | FILTER FACTOR | EXPOSURE INCREASE IN STOPS | MIRED SHIFT VALUE |
|---|---|---|---|---|
| ORANGE | CTO 1B | — | — | + 12 |
| | CTO 2B | 1.1 | — | + 24 |
| | CTO 4B | 1.3 | 1/3 | + 48 |
| | CTO 6B | 1.4 | 1/2 | + 72 |
| | CTO 8B | 1.6 | 2/3 | + 96 |
| | CTO 12B* | 2 | 1 | +144 |
| | CTO 16B | 2.5 | 1 1/3 | +192 |
| | CTO 20B | 3.2 | 1 2/3 | +240 |
| BLUE | CTB 1 | 1.3 | 1/3 | − 12 |
| | CTB 2 | 1.4 | 1/2 | − 24 |
| | CTB 4 | 2 | 1 | − 48 |
| | CTB 8 | 3.2 | 1 2/3 | − 96 |
| | CTB 12 | 5 | 2 1/3 | −144 |
| | CTB 16 | 8 | 3 | −192 |

*CTO 12B is also available in combination with ND 0.3 and ND 0.6 which require an additional 1 and 2 stops exposure increase, respectively. NOTE: CTO 6B = CTO 2B + CTO 4B

# ROSCO CINEGEL ROLLS

| STOCK NUMBER | DESCRIPTION |
|---|---|
| "STICK-ON" **ROSCOVIN** | Adheres directly to glass without taping or framing. Available as an 85 filter, various degrees of netural density, and combinations of the two. Roscovin controls daylight and balances it to indoor lighting. Standard Roscovin rolls are 54" wide x 50' long. |
| 85 | Converts daylight to 3200 K. |
| N3 | Neutral density grey. Reduces light 1 stop. |
| N6 | Neutral density grey. Reduces light 2 stops. |
| N9 | Neutral density grey. Reduces light 3 stops. |
| 85N3 | Combines 85 and N3. Converts daylight to 3200 K and reduces light 1 stop. |
| 85N6 | Combines 85 and N6. Converts daylight to 3200 K and reduces light 2 stops. |
| 85N9 | Combines 85 and N9. Converts daylight to 3200 K and reduces light 3 stops. |
| "STANDARD" **ROSCOLENE** | Durable, high clarity acetate base. Roscolene color media are available to convert daylight to 3200 K, neutral densities to reduce light intensity, and for carbon arc correction. There is also a complete range of blues to boost color temperatures and a frost to soften and diffuse. With the exception of Frost, rolls are 48" x 50 ft. |
| Cine 85 | Converts daylight to 3200 K. |
| Cine N3 | Neutral density grey. Reduces light 1 stop. |
| Cine N6 | Neutral density grey. Reduces light 2 stops. |
| Cine N9 | Neutral density grey. Reduces light 3 stops. |
| Cine MT2 | Corrects color temperature of white flame carbon arcs to 3200 K. |
| Cine MT2½ | Reduce color temperature of white flame carbon arcs. |

| | |
|---|---|
| "Daylight" Cine TD25 | Convert 3200 K to daylight. |
| Cine Booster Blue | Boosts Kelvin 800 degrees. |
| Cine ½ Booster Blue | Boosts Kelvin 400 degrees. |
| Cine 26 Blue | Light warm blue, raises color temperature and maintains good skin tones. |
| Cine ½ 26 Blue | Pale warm blue, with half the intensity of 26. |
| Cine Frost | Softens and diffuses. Rolls: 41″ x 50 ft. |
| "TOUGH" **ROSCOLAR** | Tough, heat stable polyester based Roscolar media are available in a range of blues to boost color temperature to daylight, replacing dichroics or correcting fading FAY lamps. There are Roscolars to reduce and correct carbon arcs. Rosco diffusion media soften and diffuse light, replacing silks and spun glass without their problems. |
| Tough Frost | Diffused soft, even light. Rolls: 48″ x 50 ft. |
| ½ Density Tough Frost | Diffused soft, even light. Less dense than Tough Frost. Rolls: 48″ x 50 ft. |
| Tough Silk | Diffused effect of silk with the strength of Roscolar. Rolls: 48″ x 25 ft. |
| Tough Spun | Diffuses like spun glass, without the particle irritation to skin. Rolls: 48″ x 25 ft. |
| Tough Booster Frost | Combination medium, boosts color temperature and diffuses light. Rolls: 48″ x 25 ft. |
| "Daylight" Tough Blue 50 | Converts 3200 K lights to daylight. Withstands high heat of quartz lights. Rolls: 48″ x 25 ft. |
| Tough Booster Blue | Increases Kelvin 800 degrees. Rolls: 48″ x 25 ft. |
| Tough ½ Booster Blue | Increases Kelvin 400 degrees. Rolls: 48″ x 25 ft. |
| Brute Y1 | Reduces Kelvin of white flame carbons and inhibits u.v. transmission. Rolls: 30″ x 50 ft. |
| Brute YF | Corrects yellow flame carbons and inhibits u.v. transmission. Rolls: 30″ x 50 ft. |
| | |

| ROSCO CINEGEL ROLLS | |
|---|---|
| **STOCK NUMBER** | **DESCRIPTION** |
| **ROLUX** | White diffusion material used to achieve soft lighting, producing a minimum of shadowing and eliminating point light sources. This material is on a soft base and cannot be placed too close to a hot light. Soft Frost may be stretched on frames or used over entire set. |
| **Rolux** | **White diffusion, high density for very soft lighting. Rolls: 48″ x 25 ft.** |
| **Soft Frost** | **White diffusion, less dense than Rolux, stretchable. Rolls: 54″ x 25 ft.** |
| **ROSCOLEX** PANELS | Rigid, optically clear enough to shoot through, these ⅛″ thick panels convert daylight to 3200 K, reduce light intensity, or a combination of both. Designed for fast and easy handling. They permit quick response to changing light conditions. Panels: 4 ft. x 8 ft. |
| **Roscolex 85** | **Converts daylight to 3200 K.** |
| **Roscolex N3** | **Neutral density grey. Reduce light intensity 1 stop.** |
| **Roscolex N6** | **Neutral density grey. Reduce light intensity 2 stops.** |
| **Roscolex 85N3** | **Combination 85 and neutral density. Convert daylight to 3200 K and reduce light intensity 1 stop.** |
| **Roscolex 85N6** | **Combination 85 and neutral density. Convert daylight to 3200 K and reduce light intensity 2 stops.** |
| **FLUORESCENT "DAYLIGHT" MEDIA** | New color media to balance natural daylight, dichroics or 3200 K lamps to the green cast of standard "daylight" or "cool white" fluorescent bulbs. The entire correction can then take place with one FLB filter on the lens. |

| | |
|---|---|
| **Windowgreen** | **Converts natural daylight to fluorescent "daylight". Rolls: 48″ x 50 ft.** |
| **Tough Plusgreen** | **Converts dichroics of FAY lights to fluorescent "daylight". Rolls: 48″ x 25 ft.** |
| **Tough Plusgreen 50** | **Converts 3200 K light sources to fluorescent "daylight". Rolls: 48″ x 25 ft.** |
| **ROSCOFLEX**<br>REFLECTOR BOARD MATERIAL | Fast, easy to apply reflector material. Roscoflex is available in a variety of 6 surfaces. Replaces tedious application of 100 squares of aluminum leaf. Tough, scratch and wear resistant surface is washable, scrubbable, won't pit or corrode. Sized for waste free application in rolls: 48" x 30 ft. |
| **Roscoflex "s"** | **Soft, similar to standard leaf.** |
| **Roscoflex "ss"** | **Supersoft, more diffuse than standard leaf.** |
| **Roscoflex "h"** | **Hard, matches standard hard.** |
| **Roscoflex "m"** | **Mirrorhard, bright mirror surface for long throw.** |
| **Roscoflex "g"** | **Gold, for warm reflection.** |
| **Roscoflex "c"** | **Cool blue, to boost color temperature for natural cool tones in open shadow areas.** |
| **ROSCOFLEX**<br>FEATHERFLEX "F"<br>REFLECTOR MATERIAL | Virtually weightless, tissue-thin, yet strong and durable metallized reflector material. May be taped up anywhere to provide a good soft reflective surface with minimum light loss and without affecting color temperature. Rolls: 48″ x 30 ft. |
| **Roscoflex** | **Featherflex "F"** |
| **ROSCOSCRIM** | New Rosco dual purpose material. Rugged, flexible, perforated laminate. Used as a scrim on windows or butterflies. Reduces light 2 stops without altering color temperature. One side is metallized for use as a soft reflector. Can be used as a heat deflector over camera or actors. Not for use on lights. Rolls: 48" x 25 ft. |
| **Roscoscrim** | |

## FLUORESCENT ILLUMINATION

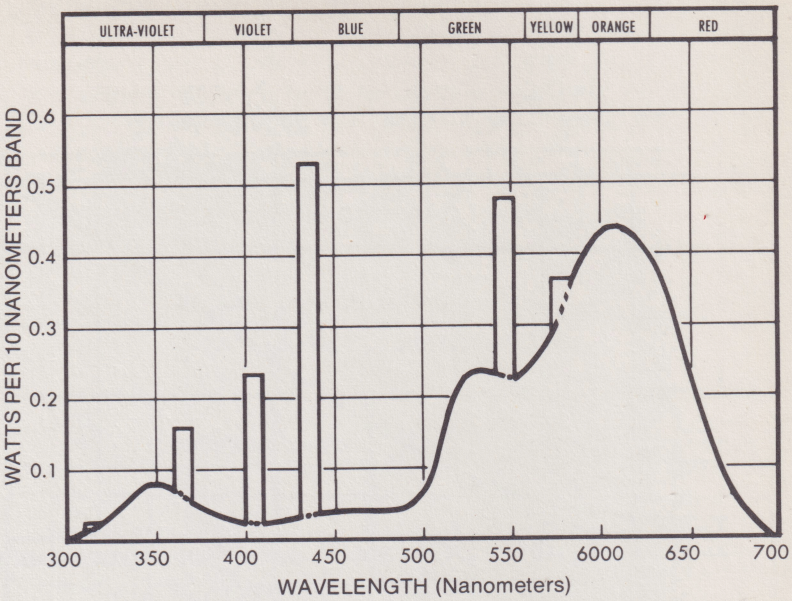
The wide use of fluorescent illumination in public buildings, factories, classrooms, offices and stores presents unique filtering problems when shooting location interiors. Long shots must be photographed with existing lighting. Closer scenes that may be illuminated with conventional tungsten lamps present a mixed light balance.

Fluorescent light appears white to the eye but it is weak in red and very strong in ultraviolet and blue. Film is more sensitive than the eye to ultraviolet and blue so color scenes shot with fluorescent light usually have a blue-green cast. Color film exposed with a daylight color balance produces best results, although the picture will appear greenish. If a tungsten color balance is used the picture will appear too blue. Filter correction in the camera while not entirely satisfactory does aid the lab in printing a system-film because the three color layers are closer in density.

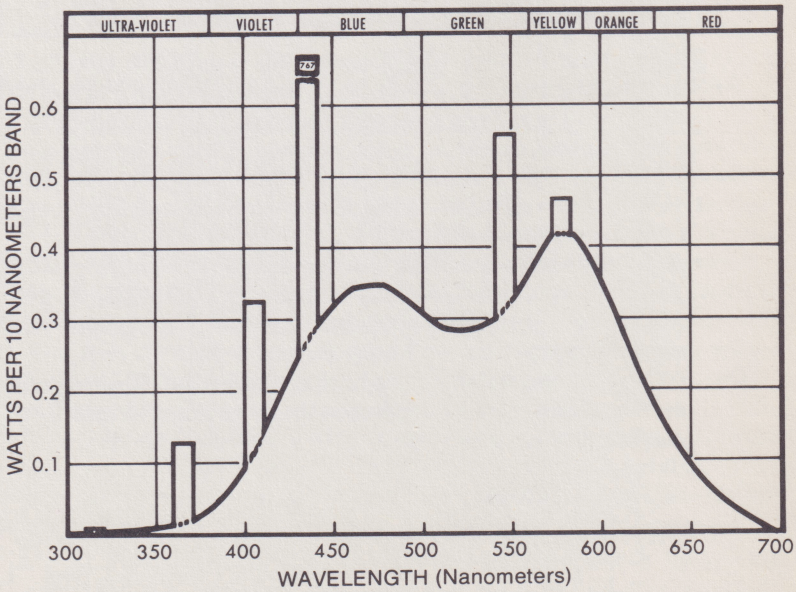
Fluorescent illumination is a *combination* of a broken or *discontinuous spectrum,* produced by the mercury arc discharge within the tube, *superimposed* on a *continuous spectrum* generated by the phosphor of the tube itself. The inside of a fluorescent tube is coated with chalk-like white powders called "phosphors." The phosphors glow brilliantly and radiate light when struck by ultraviolet rays. The invisible ultraviolet rays that excite the powder are produced from glowing mercury vapor in the tube. Fluorescent tubes display large and erratic fluctuations in light output from wavelength to wavelength. Further difficulties are encountered because there are wide variations in color and brightness among different brands, from lamp to lamp within the same brand, with voltage fluctuations, with age, with ambient temperature and even within a single AC cycle! Mixture of different types of fluorescent tubes with daylight and/or tungsten lighting further complicates filming in color.

Different types of fluorescent lamps are created by variations in the composition of the phosphor coating. There are many types of lamps available for various applications from "cool white" to "cool green" for displaying everything from men's clothing to supermarket produce! The most popular types are cool white, deluxe cool white, standard warm white, deluxe warm white, white and daylight. Deluxe lamps emit more red light than standard lamps. A deluxe warm white lamp most closely approximates the *visual* appearance of a tungsten lamp. Cool white lamps emit more blue light than white and warm white lamps, and daylight-type lamps give off the most blue light.

Fluorescent light output may be analyzed from a spectral energy distribution (SED) curve.

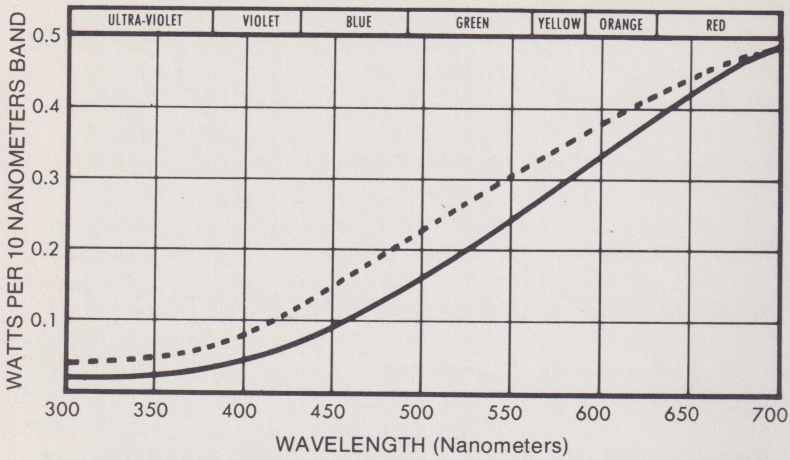



**Spectral energy distribution curve for a typical deluxe warm white fluorescent lamp.**




**Spectral energy distribution curve for a typical daylight fluorescent lamp.**

These graphs show a smooth curve with narrow vertical projections at several points along the curve. The smooth portion represents light from the glowing phosphors; the projections, light from the mercury arc inside the lamp. A tungsten lamp, however, is quite different; as depicted in the following graph.




**The solid line is the spectral energy distribution curve for a 500 watt general service tungsten lamp; the broken line, the SED curve for a No. 2 photoflood lamp.**

**Graphs reproduced with permission of Eastman Kodak Co.**

Correcting these problems by filtering the film in the camera is at best a compromise, but it will help the lab produce a better print if the three color layers receive more or less the same density and are approximately in color balance. Color film exposed under fluorescent light *without* camera filter correction will generally result in the red layer being underexposed and the green layer overexposed.

Various solutions are available but no solution is entirely satisfactory. The following solutions may be used as a guide for further testing and choosing the best technique for the photographic situation encountered.

The filtering method chosen should be based on whether the color film is exposed under fluorescent illumination *only* or *mixed* with daylight and/or tungsten light.

## FLUORESCENT ILLUMINATION ONLY

Agfa-Gevaert suggests that tests be filmed to find the particular filter or combination of filters to be used for each type of fluorescent tube. The only recommendation they make is a combination of a CC 40M and a CC 40Y for filming with so-called day-

light lamps (with a bluish tone). The film should be exposed with a Daylight color balance and the exposure increased 2/3 stop.

Eastman Color Compensating filters, either singly or in various combinations, will improve color reproduction so that it falls within a color balance and density range that the lab may color correct when the film is printed.

Eastman makes the following fluorescent filter recommendations and suggest they be used as a basis for testing only.

**EASTMAN and KODAK CINE COLOR FILMS**

**FILTERS FOR FLUORESCENT LIGHT**

| TYPE OF LAMP | DAYLIGHT | WHITE | WARM WHITE | WARM WHITE DELUXE | COOL WHITE | COOL WHITE DELUXE |
|---|---|---|---|---|---|---|
| FILMS BALANCED FOR 3200 K | 85B +30M +10Y +1 STOP | 40M +40Y +1 STOP | 30M +20Y +1 STOP | 10Y +1/3 STOP | 50M +60Y +1 1/3 STOP | 10M +30Y +2/3 STOP |
| FILMS BALANCED FOR DAYLIGHT | 40M +30Y +1 STOP | 20C +30M +1 STOP | 40C +40M +1 1/3 STOP | 60C +30M +1 2/3 STOP | 30M +2/3 STOP | 30C +20M +1 STOP |

TIFFEN OPTICAL COMPANY offers two fluorescent light filters — the FL-D (for Daylight type color film) and the FL-B (for 3200 K balanced color film). These filters are a combination of various CC filters, and an 85 plus CC's in the case of the FL-B. They thus permit the cameraman to use a single filter, rather than a combination of several filters. They are somewhat limited in that they provide a compromise filter correction. However, they will work with most fluorescent light situations.

Industrial in-plant cameramen filming day to day in factories, or similar interior locations under consistent fluorescent illumination should work out their own particular series of CC filters that produces best results with their particular lighting. The lab should be consulted when running tests so that their recommendations may be taken into consideration. The original camera film that appears visually best may *not* offer the lab the best printer correction. Often an off-color original permits greater color correction when printed.

GAF makes the following recommendations for their Color Reversal Camera films.

| GAF CINE COLOR FILMS<br>FILTERS FOR FLUORESCENT LIGHT | | | | | | |
|---|---|---|---|---|---|---|
| TYPE OF LAMP | DAYLIGHT | WHITE | WARM WHITE | WARM WHITE DELUXE | COOL WHITE | SOFT WHITE |
| FILMS BALANCED FOR 3200 K | 50R +50Y +1 2/3 STOP | 20R +20Y +2/3 STOP | 10R +20Y +2/3 STOP | 10R +20Y +2/3 STOP | 40R +30Y +1 STOP | 10R +30Y +2/3 STOP |
| FILMS BALANCED FOR DAYLIGHT | 10B +1/3 STOP | 20B +20C +1 STOP | 10B +30C +1 STOP | 20B +30C +1 1/3 STOP | 10B +10C +2/3 STOP | 10B +30C +1 STOP |

Choice of CC filters may be narrowed down for testing by checking with the factory's electrical department to find out what type of lamps are installed. This will also help whenever extensive filming must be done on location and there is no time for shooting a test and having it processed. Newsreel cameramen and others with no time for such inquiries may assume that the lamps are white, warm white, or cool white, because sales figures indicate that these lead all other types in use by a wide margin.

Good results have been reported with so-called "Correlated 3200 K" fluorescent lamps. These tubes not only visually resemble light from a 3200 K tungsten lamp but reproduce color images that are similar. Tungsten balanced color film may be exposed without filters, thus taking advantage of the film's full speed. Feature film directors of photography who film location interiors carry a supply of these lamps so that they may replace the fluorescent tubes in ceiling fixtures whenever practical. This is a matter worth looking into for any cameraman who works extensively on location and wishes to solve the fluorescent problem. Modern fluorescent lamps are being improved by the introduction of new phosphors which vastly increase the illumination and after-glow characteristics of the phosphor itself. Since the illumination from the *phosphors* has a *continuous spectrum* this improves the SED of the light source.

Long shots may be made with existing ceiling illumination. Closer scenes will require additional front and side lighting. Use of conventional tungsten lamps will create a *mixed light* situation. The warm "reddish" film correction employed for filtering the existing ceiling fluorescent light will cause the flesh tones of foreground subjects illuminated by the 3200 K lamps to become overly red. If the lab corrects for the foreground — the correctly filtered background will be off color! Therefore, do not use unfiltered tungsten lighting when a *camera filter* is being used to correct the fluorescent illumination.

The foreground may be illuminated with the same type of fluorescent lamps as used in the ceiling fixtures. In-plant cameramen who do a great deal of factory filming may improvise fluorescent fixtures with mounts that fit portable light stands. Fluorescent lamps change color as they warm up. Turn them on at least ten minutes before shooting the scene, or leave them on continuously.

## MIXED ILLUMINATION

Fluorescent illumination presents additional problems when mixed with daylight and/or tungsten illumination.

ROSCO LABORATORIES new *Fluorescent "Daylight" Media* is available in CINEGEL rolls for *converting* daylight or artificial light so that it approximates the greenish fluorescent illumination. This makes it possible to mix and color balance various light sources and make a single correction by positioning a TIFFEN FL-B filter on the camera lens. Although this may appear to be a rather unorthodox solution to the mixed light problem, it does offer a simple method for mixing and matching fluorescent light, daylight and tungsten illumination. Any additional color correction, if required, may be made when the lab prints the film. Since the overall filter correction is based on "greenish" daylight, the color film should be exposed by employing its Daylight Exposure Index and increasing exposure 1 stop for the filter, or by using its *Effective Exposure Index,* which in this case would be one-half its normal E.I. to account for the filter's exposure increase.

CINEGEL rolls are available in "Windowgreen" for covering windows; "Tough Plusgreen" for positioning in front of FAY lights (PAR bulbs with daylight dichroic coatings); and "Tough Plusgreen 50" for positioning in front of conventional 3200 K tungsten or tungsten-halogen quartz lamps.

If CINEGEL is unavailable there are lighting techniques that may be improvised for an occasional scene, but they should be used only in an emergency — not for extensive filming if theatrical print quality is desired.

Unfiltered tungsten light may be bounced off average height *white* ceilings in small rooms. The lamps should be positioned a few feet below the ceiling, aimed upward and tilted slightly in the direction of the subject. If quartz lamps are used do not position them too close to the ceiling or the paint will be damaged! The yellowish tungsten light *adds yellow-orange-red* to the *minus-red* fluorescent illumination and thus tends to fill in its spectral deficiency. Expose the film with a Daylight Exposure Index and use an 85 filter in front of the lens, if filming with 3200 K tungsten balanced color film. This improvised technique does not always produce correct color reproduction but it does improve flesh tones and it snaps up lighting contrast which relieves the deadly flatness of fluorescent illumination. Distant backgrounds *not* illuminated by the bounce light will, of course, appear greenish or blue-green. This is the reason this lighting technique works best in small rooms, such as classrooms, where the background is close to the subject.

Newsreel, documentary, or cinema-verité cameramen who work in close to their subjects may simply overpower the fluorescent illumination by pouring in sufficient tungsten-halogen light to make the exposure. Backgrounds, or other areas that are not illuminated by the tungsten light, will appear uncorrected.

A three-color meter, such as the SPECTRA FILM-BALANCED THREE-COLOR METER or the MINOLTA THREE-COLOR METER should be employed to properly evaluate the precise spectral energy distribution (SED) of fluorescent illumination. Readings with two-color meters are meaningless. A three-color reading will indicate the precise CC filters required to correct the color deficiency in the fluorescent light.

Polaroid color film provides an excellent means for *on-the-spot testing* of fluorescent illumination to find the filter required for best results. Although Polaroid color film is daylight balanced and has good color saturation, it has slightly pinkish flesh tones and very limited exposure latitude. However, with a little experimental work and comparing of color prints and movie film it is possible to develop a "color eye" for translating the Polaroid color print into cine camera color film values. Have the player in the scene hold up the Workbook's gray card and color patches alongside his face so that the test shot is a close-up of all three. Try various CC filters or the Tiffen FL-B or FL-D to find the best correction for the prevailing light.

## FLUORESCENT LIGHT FLUCTUATIONS

Motion pictures filmed with fluorescent illumination may "flicker" because the gas in fluorescent tubes discharges with

the cycle of the AC current. Two distinct kinds of light are emitted by fluorescent tubes: (1) the light of the gas discharge (which is shorter than the total time of 1/2 cycle), and (2) the light produced by the fluorescent coating. The AC voltage has to build up after it crosses the zero line before the gas radiates light energy. The phosphor coating fluoresces *after* the radiating energy of the gas discharge has activated it. The coating continues to fluoresce for a time after the energy discharge has completed a 1/2 cycle. This "afterglow" is called *decay time*. Afterglow characteristics of modern fluorescent tubes have been vastly improved and this helps a great deal to smooth out the light.

The gas discharges with the cycle of the AC current. There are twice as many pulses as cycles: 50 Hz (cycles) has 100 light pulses, 60 Hz has 120. The cine camera problem would be simplified if the shutter opened and closed *instantly* so that each frame of film is exposed for the same number of pulses. If the camera is running in sync with the AC line current each frame receives the same number of light pulses and exposure is even. If the camera "drifts" (which may happen when filming with a "wild" motor) then one frame may receive 4 light pulses and the next only 3, and an occasional frame may record only 3½ light pulses. The difference in exposure between 3 and 4 light pulses is 1/2 stop. The resulting unevenly exposed series of frames, therefore, will flicker when projected.

This problem may be solved by shooting with a sync or constant speed motor, so that each frame will receive the same number of light pulses. Another problem is also present, however, because exposure time must be longer than 1/60th second with 60 Hz line current and 1/50th second with 50 Hz line current. The camera shutter must have an opening of at least 180 degrees (1/48th second), and a wider shutter would be better, particularly with a 50 Hz current. A 35mm camera with a 200 degree shutter would be better, and 16mm cameras, such as the Mitchell or Maurer, with 235 degree shutters, would be an excellent choice. Super 8 cameras, with 230 degree shutters, such as the Eastman XL Super 8 camera, would insure flickerless films. Several Super 8 and 16mm cameras have shutters with openings *less than 180 degrees* — they should not be used for filming with fluorescent light.

The shorter exposure time caused by too narrow a shutter angle and/or higher than normal camera frame rate, may also cause *variations in color* because *part* of the frame will record primarily discharge light and part primarily fluorescent or decay light. Therefore, part of the frame, the top for instance, may be exposed by light of one color configuration and the rest of the frame by light of another color configuration.

## MIXED ILLUMINATION

Illumination is mixed whenever two or more light sources with different *spectral energy distribution* curves are used to expose the film. This occurs outdoors when artificial "booster" lights are used to lighten sun shadows. It occurs indoors when daylight and tungsten light illuminate a room, or when fluorescent light is mixed with daylight and/or tungsten light.

If a color correct picture is required all light sources used to illuminate the scene should be similar in color quality. It is preferable that they match the color balance of the film but if they are at least similar a *single overall filter correction* may be made in the camera or when the film is printed. Note that this applies only to *overall color* correction. *Local color* correction, such as the bluish daylight from a window on one side of the picture — cannot be color corrected in the camera or by the lab to match the correctly color balanced tungsten illuminated portion of the scene on the opposite side!

If a special color effect is desired — then anything goes! Colored gels may be positioned in front of lights and various light sources may be mixed. However, a knowledge of color temperature and mixed lighting is helpful in order to plan such color effects and be assured that the results will be as desired.

A decision must be made when filming with mixed illumination whether it is best to expose the film with a *daylight* or *tungsten* color balance. In some instances, no decision is required since the cameraman must expose for the dominant light source. In many situations several factors must be considered: size of area being filmed, intensity of existing light source, photographic lighting equipment and electrical power available, color effect required, whether shooting day or night, or *simulated* day-for-night, and whether the scenes being filmed have to inter-cut with other scenes filmed under other light conditions.

### DAYLIGHT COLOR BALANCE — EXTERIORS

The cameraman has no choice on daylighted exteriors. Since sunlight and/or skylight, are dominant it is necessary to *convert tungsten lights*, used for "boosters" to lighten shadows, to daylight balance. This may be accomplished by positioning daylight dichroic filters in front of tungsten or tungsten-halogen "quartz" lamps to convert them to daylight color balance, or FAY lights (PAR-type sealed-beam "quartz" lamps with daylight dichroic *coated* filters) may be employed. ROSCO "booster blue" color media of various types may also be positioned in front of tungsten lamps to convert them to daylight quality.

Big-budget camera crews may use "Brute" arc lamps with "white flame" daylight-type carbons and Y-1 (straw-colored) filter, for exterior booster light. Or, new lightweight arc lamps, which are gaining popularity. Xenon arc lamps may also be employed. Small camera crews generally prefer the lighter-weight,

more easily handled, FAY lights, or "quartz" lights with blue gels. (SEE: *Filter Nomograms,* for daylight-type lamps available.)

## DAYLIGHT COLOR BALANCE — INTERIORS

Daylight interiors may be filmed with a daylight color balance. Use daylight color balanced film or 3200 K tungsten color balanced film with the Wratten No. 85 filter. Use arc lights with "white flame" carbons (if very large areas are involved), or tungsten or tungsten-halogen "quartz" lamps with daylight dichroic filters. Rosco "daylight" blue color media (available in various types) may also be positioned in front of tungsten lights to convert them to daylight color quality. Blue daylight-type No. 2 or No. 4 photofloods may also be used but their color temperature is rather low (approximately 4800 K) so their light is warmer than average daylight. Any, or all, of these daylight-type lamps may be employed singly or in any combination, to provide an *approximate* color match to the daylight illuminating the room. There is no need to filter the windows unless the exterior scene is brilliant and/or the daylight coming through the window is out of exposure-balance with the artificially illuminated interior. In that case *neutral density filters* (various types of Rosco filter material are available for this purpose) may be employed to *lower the daylight intensity* and balance the exterior with the interior.

Shooting location interiors with daylight balance is generally employed only when large windows or skylights are involved, such as found in large public buildings with a great deal of glass, or airplane hangars or factories with large doors or windows. In most cases, the daylight effect is natural and desirable because it not only provides key light but casts sun and shadow patterns on walls and floors that enhances the sunny effect. The daylight balanced artificial light should provide fill light only. Do not overlight the players or an artificial effect will result. The fill light should appear to be ambient bounced daylight, so it should be balanced to the sun/key and not overpower it.

## TUNGSTEN COLOR BALANCE — INTERIORS

Daylighted interiors may also be filmed with a tungsten color balance. Unfiltered tungsten, tungsten-halogen "quartz" lamps, "white" photofloods, or arcs with tungsten balanced "yellow flame" carbons (with YF-101 filters) may be used singly or in any combination. Windows should be covered with 85-type filter gel (similar to the Wratten No. 85 filter used on the camera lens to convert tungsten balanced color film to daylight). Rosco makes several types of 85, either singly or in combination with neutral densities (N3, N6, N9). The 85 window gel *converts* the daylight to tungsten color quality. The neutral density filters *lower the intensity* of the daylight (and the exterior scene through the window) by 1, 2, or 3 stops, respectively.

Shooting with tungsten balance takes full advantage of film speed and light intensity since filters are not required on lens or lights. Artificial light may reinforce the daylight, for a daylight key-light effect. Or, it may be used as fill light to balance the daylight. Or, the room may be illuminated for an interior light effect as if lighted by lamps or other light sources in the scene — and the daylight appear as simply incidental. The latter would work best in the late afternoon or on drab or dull days when daylight is weak and artificial lighting is turned on.

## EXTERIOR-INTERIOR COLOR & LIGHT BALANCE

Location interiors and the view through the window will appear properly exposed and correctly color balanced if 85 window gels and neutral densities (if required) are used together with tungsten balanced lighting. If 85 gels and neutral densities (if required) are *not* used, the view through the window will appear bluish, overexposed (or burned out, if vastly overexposed) and the interior will appear bluish whenever strong sunlight mixes with the tungsten lighting.

Many low-budget producers, influenced by TV commercials, prefer flaring burned out windows. Or, they are not concerned with the cameraman's color and light balancing problems. In such cases, the best that can be done is to shoot away from the windows as much as possible, keep the players out of direct sunlight and strive to at least illuminate them properly with tungsten light that overpowers the ambient daylight, if sufficient lights and power are available. Players are often filmed inside moving cars by the light of a battery-powered "Sun Gun" or two. If the exterior is brilliantly sunny it will be vastly overexposed at the T-Stop used to properly expose the players. The problem may be easily solved in a few minutes by simply applying self-adhering "Roscovin" 85 plus ND to the car windows to bring the exterior into color and light balance with the artificially lighted interior.

The appearance of the exterior scene will depend on subject matter, time of day, weather conditions, sun angle, etc. If the outdoor scene is shaded or faces north — it will appear bluish even with the 85 on the window. This is generally the case if the sun pours into the room because then the exterior scene is backlighted. A good exposure balance requires that the exterior appear slightly "hotter" than the interior. Most professional cinematographers prefer that the exterior be two stops "hotter" in exposure value than the interior. If, for example, the exterior (read with a reflected spot meter through the window 85 or combination 85/ND) reads T-8, then the artificially illuminated interior should read T-4 (read with an incident light meter). The use of neutral density filters in combination with the 85 permits easier balancing when the exterior is brilliant, say on the order of T-16, or more. The 85N6, for example, will lower the light two stops,

for a T-8 reading. (Note the 85 adds 2/3 stop, so use the film's Tungsten balance E.I. for the spot meter reading through the window, which in effects takes this into account.) the 85/N9 would result in a T-5.6 reading which would permit an artificial light level of T-2.8, for the same two stops difference in exposure between interior and exterior.

Three stops difference is the most that should be employed if detail is desired in the exterior scene. Greater than three stops "hotter" exterior exposure will generally burn up a bright exterior. However, a shaded scene, or a dark building or foliage, or other low key exterior may tolerate greater difference in exposure.

Day-for-night interior scenes with mixed daylight and tungsten light may be photographed by *not* using the 85 and only employing neutral density filters to *darken* the exterior. The outside scene will thus be rendered bluish and appear as a typical "moonlight" illuminated background. Or, blue gels may be positioned over the window, plus ND's if required, to darken and add blue to the exterior scene. This may result in greater bluishness than desired. A "hot" bald sky may often be blued by positioning blue gels so that they cover the sky only, and using ND's overall to darken the exterior. A bit of experimenting will show what can and cannot be done. Use film short ends to shoot day-for-night interior tests to find out how different techniques work and how the screened results compare.

Lighted exteriors, displaying street lights, signs, auto headlights, etc., may be filmed at twilight's *magic moment* — the 10 to 15 minutes after the sun goes down and there is still sufficient ambient daylight bounced off the sky to pick up some bluish detail in the exterior. The combination of illuminated night, with just enough daylight for the bluish effect — and the tungsten illuminated interior, can be easily balanced at twilight. This method is good for only a scene or two because of the short time interval available before nightfall. However, a sequence may be filmed by carefully planning a scene or two each night and rehearsing the action and being ready to roll when the sun sets below the horizon.

If color media is unavailable, an occasional scene may be filmed in an emergency by pulling drapes across the windows, or partially closing venetian blinds, so that the exterior daylight is lowered in intensity and only a bit of bluish light shows through. If a light effect only may be used, and the exterior scene need not appear through the window, a "soft frost" type of light diffusion material may be positioned against the window. Remember that curtains, drapes, diffusers, etc., will all appear bluish, or have blue added to their color, if the window is *not* filtered with 85. Players should be pulled away from the windows so that the unfiltered daylight does not strike them. There are times when mixed bluish daylight and tungsten interior lighting may provide an interesting pictorial effect. Bluish winter sunlight through a window may look perfectly natural, particularly if combined with a firelight effect employed to illuminate two players lounging in front of a roaring fire.

## DAY-FOR-NIGHT SCENES

Day-for-night scenes are *simulated* night scenes exposed during daylight hours or at twilight. They are scenes in which sunlight substitutes for moonlight. Or, scenes supposedly illuminated by moonlight but also featuring artificially lighted streets, or other areas and depicting light sources, such as car headlights, street lamps, lighted windows and signs.

The speed of modern color camera films and the additional effective speed afforded by push processing makes it practical to shoot *night-for-night* scenes. However, there are night scenes that are impractical to illuminate artificially and actually film at night — such as a herd of stampeding cattle — or scenes that are best filmed at twilight — such as a street scene featuring lighted areas and light sources but depicting a bit of detail in buildings and a dark blue sky. Shooting such scenes day-for-night eliminates the need for artificial light, electrical crew, and all of the additional problems and expense of night shooting — and delivers excellent pictorial results at small cost.

### SCREEN APPEARANCE OF DAY-FOR-NIGHT SCENES

It is difficult to truly simulate night in day-for-night scenes because actual night scenes consist of mostly dark shadowed areas with a few light accents — but daylight scenes consist of mostly highlight areas with a few shadow accents!

Controversy has always existed among cinematographers, art directors, directors, film editors and film processing personnel as to the appearance of day-for-night scenes that simulate moonlight. What constitutes a "night" scene on the screen has been argued and variously interpreted from motion picture's earliest productions. Pioneer movie makers simply printed black and white day scenes darker and tinted them blue for a night effect. "Bluish moonlight" was a technique borrowed from the theater where blue gels were positioned in front of the lights for a moonlight effect. Blue moonlight has been a lighting fallacy for many years and is so deeply entrenched and accepted that even modern cinematographers and film labs find it difficult to discard.

The moon is a neutral gray body that reflects sunlight, so that its color is the same as that of the sun. A time exposure made by actual moonlight will prove this fact. The apparent bluish color of moonlight is due to the shift in the peak sensitivity of the eye in dim light to the bluish portion of the spectrum. So, a slightly bluish effect is not entirely without physical foundation! It would have to be very subtle, however, to duplicate what the eye sees.

Moonlight is highly diffused so its shadows are much softer than those cast by specular sunlight.

An acceptable night scene, regardless of how it is filmed, whether day-for-night or night-for-night, should possess the following characteristics: overall shadowed low-key appearance, dark blue or black sky, players key-lighted from the side or by rear cross-lighting so that the side of their faces nearest the camera are shadowed, little or no fill light, rich black shadows with soft edges, distinct separation of players and backgrounds, slightly bluish effect on areas supposedly illuminated by moonlight, warm yellowish effect on areas illuminated by artificial light. Harsh, contrasty burned out highlights and black shadows should be avoided. Day-for-night scenes should not include large expanses of bald white sky, "hot" sunlighted streets, sandy beaches, light toned buildings or light backgrounds.

Simulated moonlight scenes should be filmed in bright sunlight. Overcast or dull days when the sun is obscured will produce poor results because contrast will be too flat, specular reflections will be missing and cast shadows will be absent. The sun should key the scene from the side, rear, or preferably from a rear three-quarter angle. A low sun will produce long shadows toward the camera that will back and edge light players, buildings, trees, foliage, etc. This also creates heavily shadowed areas that are typical of real night. A front or front-three-quarter sun angle should not be employed because it will illuminate the entire scene and flatten the overall effect.

## FILTERS & EXPOSURE

The desired bluish effect may be recorded by the cameraman on the original film or produced by the lab when the film is printed. Film makers and labs differ in their handling of the problem so it is wise to consult the lab and get their recommendations and then shoot tests for comparison of various techniques.

Generally it is best to pull the Wratten 85 filter when filming with reversal tungsten balanced color camera film and underexpose about one-half stop. Remember that the filter has a two-third stop value, so the film must be underexposed about one and one-third stops, if the Daylight E.I. is used. There is no need for greater underexposure if the scene is properly side or back-lighted and consists of mostly shadowed or dark areas. The lab may later print the scene darker, if desired, and even add additional blue or create the desired color effect. If the bluish effect is too great on the original film a Wratten 2C (no factor) may be employed to filter out excess ultraviolet and thus aid the lab when printing the film by bringing it into better color printing balance.

The overall bluishness produced by shooting tungsten balanced color film in daylight without the Wratten 85 may be overcome by employing gold reflectors on players faces or illuminating them with 3200 K booster lights. Flesh tones will thus be warm and the backgrounds bluish. Such fill light should appear as ambient light only if the sun is acting as a "moonlight" key. Slight underexposure will produce the best results — players should not be over illuminated or they will appear obviously front lighted.

The Wratten 85 is generally retained when shooting negative color film and the scene underexposed one and one-half to two stops. The lab will add the bluish effect when the negative is printed. The cameraman may, however, create his own bluish effect by using the 85 plus a Kodak 82 (blue) filter, or any other bluish filter in the 82 series. Many cameramen use a bluish filter so the day-for-night scenes will look well in the one-light dailies! If a series of such scenes are filmed, however, it is best to ask the lab for a one-light daily print with the desired bluish color effect.

Many cameramen prefer to use a "conversion" filter that provides *less correction* than the Wratten 85 — such as the 85C or the 81EF. Since underexposure tends to shift flesh tones toward red, a greenish filter, such as the CC20G or CC30G, may be added. Even filters designed for black and white film offer opportunities for day-for-night effects with color film. The yellow K1 (Wratten No. 3) may be used to counteract the bluishness of shooting without the 85 by adding yellow. The K1 is available in combination with a neutral density: the 3N5 (No. 3 plus ND 0.5), so it can provide partial correction and underexposure simultaneously. The entire Kodak 81 series are worth testing. Also test Harrison's Coral series C-1/8, C-1/4 and C-1/2. Remember that final filtering need not be accomplished entirely in the camera *or* by the lab — a combination of camera and lab filtering may produce the desired color effect.

Avoid vastly underexposing negative color film or it will result in a thin negative that produces a grayish looking print. A good night shot requires rich blacks and good contrast. A negative must have sufficient density to print on a high light number to produce such blacks. Best results are obtained when the highlights are correctly exposed, or only slightly underexposed, and the shadows have little or no exposure. This is best handled with correct sun angle and camera angle that creates heavy shadow effects. The negative with greater density may *always* be printed down for a darker effect — but a negative that is too thin requires a low light number that cannot produce rich black shadows. Remember that the highlights must have sufficient density to require a high light number that will produce good

blacks in the print. This is a particularly important point that cameramen with experience shooting reversal film should bear in mind. Switching from reversal to negative requires *reverse thinking* — vastly underexposing a negative, unlike a reversal original, will *not* produce inky black shadows!

The required amount of underexposure may be handled in several ways but the simplest and best method is to employ neutral density filters and ignore their Cine Factor. ND's are available in increments of one-third stop, so choose the particular ND that delivers the required underexposure and position it in front of or behind the camera lens and do *not* alter the T-Stop.

Or, the T-Stop may be reduced the required amount, but this may be difficult in bright sunlight when the lens is already working at a small aperture. Or, the shutter angle may be reduced to cut the exposure. This will work well on more or less static scenes but should not be done on scenes involving moving players and/or moving camera or an undesirable "chatter" effect may result.

A *graduated* ND, in which a portion of the glass filter has density and the remainder is clear, may be employed to darken the sky only, or turned upside-down to cut down exposure on a "hot" area of high reflectance, such as a snow covered field or sandy beach or even a brilliantly sunlighted street or sidewalk. Graduated ND's are available from Harrison and other filter manufacturers, in various densities and square or rectangular sizes to fit professional cine camera matte boxes. They may also be used in combination with overall ND's for both lowering the light intensity and bringing the scene into exposure balance.

Polarizing filters may be used for darkening skies when the sun is directly overhead or at right angles to the camera. A polarizing filter should not be used if the camera must be panned or if several scenes must be shot from opposing angles because sky density and color will vary. While polarizing filters are an excellent method for darkening blue skies, they can only be employed effectively for motion pictures under certain conditions. They are useful for isolated shots that can be set up to match a particular sun and sky condition at the time of shooting. If several shots must be filmed for a matched sequence the camera must *move in* (not to the side) to preserve the *camera-sun angle relationship* or the polarization will change and the sky value altered. Polarizing filters may also be used in combination with neutral density or other filters.

## TWILIGHT'S "MAGIC MOMENT"

Very effective day-for-night scenes may be photographed at twilight's "magic moment" just after sunset, while there is still

sufficient ambient daylight and street lights, auto headlights, store windows and signs begin to light up. The Wratten 85 filter is pulled. The fading daylight provides a soft bluish "moonlight" effect that provides beautiful color contrast for the yellowish light sources. Since the light sources are all below 3200 K they will record with a warmish glow. The effect is enhanced if shot during a light rain or after a rain, so that light sources are reflected in wet pavement. Magic moment shooting must be carefully planned so that the camera is ready to roll as soon as the sun drops below the horizon because only ten to fifteen minutes is available for filming before night sets in. A long sequence should be planned for several nights if matched color and light effects are desirable. Generally only the long shot need be filmed precisely at twilight — the closer scenes may be shot night-for-night. Summer twilight lasts longer than winter, so filming should be planned accordingly.

The effect of a lighted interior, such as a long shot of a house with lighted windows, may be best simulated at twilight by positioning tracing paper, or light diffusion material, over the windows and back-lighting from inside. The lights aimed at the covered windows should have yellow gels for a warmer effect. This technique is simple and more convincing than lighting the entire room — which is necessary only on closer shots where the camera actually sees into the interior.

Magic moment shots may be slightly underexposed or exposed normally and later printed darker for any desired effect. Generally, it will not be necessary to push process the film. An incident light meter will be found best for reading the ambient fading daylight.

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## ORIGINAL COLOR FILM STORAGE

Eastman Kodak Company recommends that Ektachrome Commerical film should be wound in a *base-up* position for maximum protection in storage. This *emulsion-in* position achieves more positive emulsion protection and greatly reduces any tendency towards sticking when original film is stored under less than ideal conditions.

## FILM PROCESSING DEFINITIONS

Cinematographers should understand a few film processing definitions that also apply to exposure. A knowledge of *development fog, gamma* and *H and D curves* will prove very useful in comprehending how exposure and development are plotted and how the shadows, middle tones and highlights vary in density and may be altered by varying exposure. Normal and push processing may also be better understood if the cameraman comprehends how differences in density, contrast and graininess affect print quality. Study the H and D curves in the Workbook, shoot tests to find out what happens when color film is over and underexposed and push processed. Get acquainted with the lab timer, find out what he has to do to correct mistakes made when the original film is wrongly exposed and/or photographed with the wrong light balance. Also, learn how he can produce overall color effects when the original is printed. An experienced cinematographer thinks not only of overall exposure and color balance — he thinks of *each layer* of the film possessing a particular colored density. The lab can either *correct* color deficiencies in each layer — to bring the print back to normal — or, *create* color effects by manipulating the additive printer lights.

### DEVELOPMENT FOG

Development fog is the result of development of *unexposed* silver halide grains. Fog produces density where there is no exposure. All films possess a basic fog density. Extending development time, such as push-processing, *increases* this density. The *base* of the film also possesses some density, so this *overall density* is referred to as *fog plus base.*

### GAMMA

Gamma is associated with the inherent contrast of the film and development. The more inherently contrasty the film, the higher its gamma. Kodachrome II, a direct-projection-type color camera film, is higher in gamma than Ekatachrome Commercial, a soft original system-type color camera film intended for production of release prints.

Gamma is a number that represents the *ratio* of the luminance range of the original scene to the range of densities on the straight line portion of the H and D curve. The ratio would be 1:1, or a gamma of "1" when the density range of the picture is approximately equal to the luminance range of the original scene. Less than "1" if the picture has lower contrast; more than "1" if the pic-

ture has higher contrast. In actual practice, however, projection gamma must be higher than "1" due to flare and other imperfections in printing film and projection that cause losses which lower contrast. Print stocks have higher gammas so that the projected picture displays snap and contrast which is acceptable to the viewer.

Gamma also defines the photographic changes made by changes in exposures. Gamma is a measure of degree of development of a film. Films developed to the same gamma show comparable tone reproduction. Optimum gamma is called *gamma infinity* — beyond which no change is produced except increased fog density. All gamma measurements are made on the straight line portion of the curve. The steepness of the slope of the straight line is a measure of the contrast of the film. The steeper the slope, the greater the contrast, the higher the gamma.

Gamma may be varied over a wide range when developing black and white films. It is more or less a fixed quantity in color film and processing. Variations in black and white processing, particularly push-processing, can cause vast differences in the contrast of a black and white negative or reversal film. However, practical variations in color processing produces no great change in gamma. Wide variations, produced by vastly under or over developing the original camera film, will cause gamma changes — but such changes in development are not practical because the three color layers become unbalanced. This can result in pink shadows and green highlights or some such weird results. So, except for special color effects, development of color film is standardized to a fixed time and temperature that produces the gamma required for proper contrast and color balance.

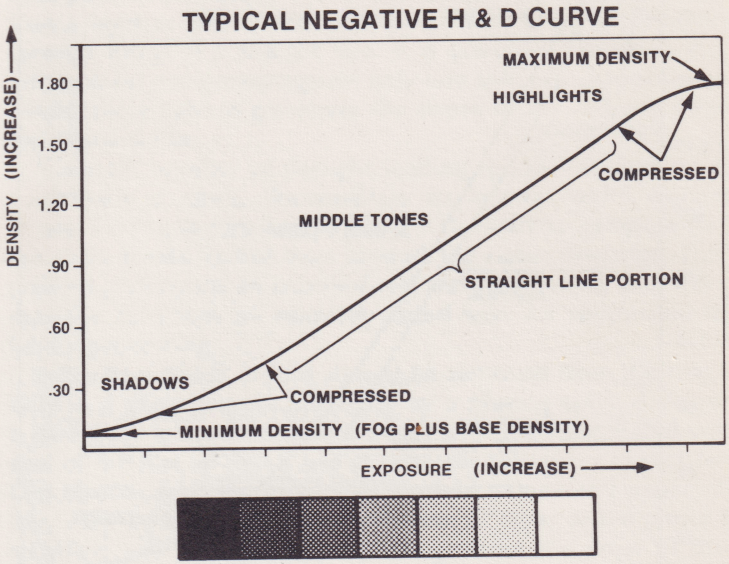
## H AND D CURVE

H and D does *not* mean *highlight and density* as many cameramen and lab personnel mistakenly believe! H and D refers to Hurter and Driffield, two British scientists and amateur photographers who were the first to work out methods, around 1890, for measuring the sensitivity of photographic plates, involving the measurement of light intensities and the resultant densities. They also worked on the theory of the *latent image*, its development and the control of the development factor — or *gamma*.

The H and D curve is also called the *characteristic curve* or the *D-log-E* curve. The curve defines the *ratio* of the density with the logarithm of exposure. It is a type of *response curve* that shows how light acts on a photographic material and produces density on development. The average scene is made up of many surfaces with various reflectance values. These different exposures pro-

duce a range of densities on development. These densities may be plotted against the logarithm of the exposure which produced them. The density value from a given exposure may thus be read from the curve. An understanding of logarithms is helpful but not essential to interpreting H and D curves. The important thing about a logarithmic scale of exposures is that a certain distance along the scale corresponds to an increase in exposure by a constant factor. For example, an increase of the log exposure by 0.3 (which is similar in density to an ND 0.3 filter, or 1 stop) always corresponds to a doubling of the exposure itself.

The H & D curve shown is for negative films so it slopes from lower left to upper right. Reading from left to right shows an increase in exposure. Reading from bottom to top shows an increase in density.




**The shaded blocks represent the DELUXE GENERAL Gray Scale.**

Density builds slowly in the "toe" portion of the curve, so *shadows* are *compressed* in tonal values.

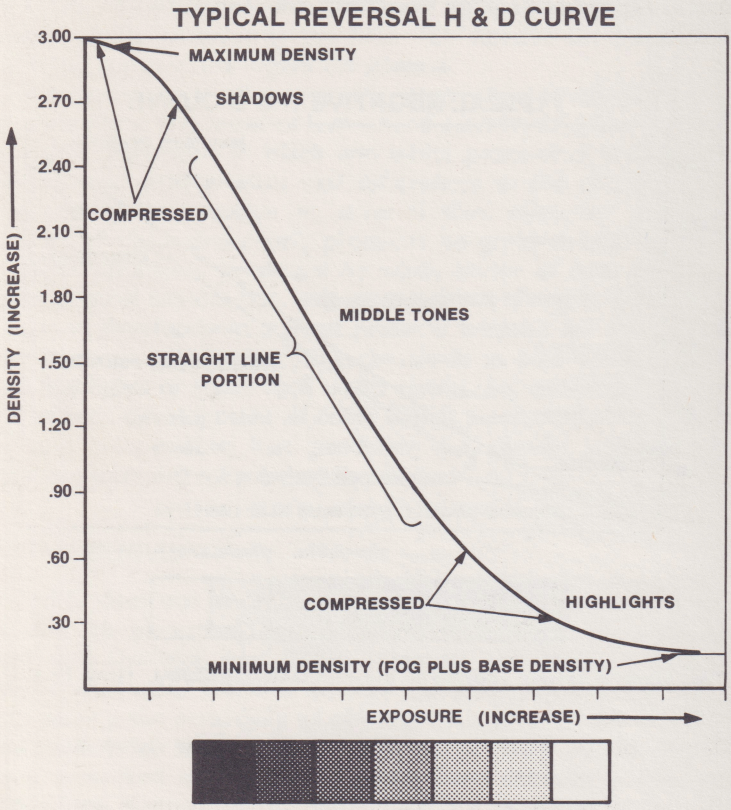
Density increases at a constant rate as exposure is increased. This produces a *straight line* which represents the *middle tones*. The straight line portion of the curve is where gamma is plotted.

As exposure is further increased the density increase slows down as the line curves to horizontal. This portion of the curve records the highlights and is referred to as the "shoulder." The horizontal line portion is referred to as D-max — or maximum

density. D-max is where further exposure will *not* produce an increase in density because all of the silver has been developed.

Note that the *toe and shoulder compress shadows and highlights* respectively. Only the *tonal values* reproduced on the *straight line* portion of the curve bear a *proportional relationship to the original scene.*

The H & D curve for a reversal film slopes from upper left to lower right because density *decreases* as exposure is increased. The H & D curve for a print — regardless of how made (from a negative, an intermediate, an internegative, a reversal original or master) will resemble a reversal curve in its relationship to the original scene.




**The tonal values of a reversal curve are the same as those of the original scene. Highlights have the least density, shadows the greatest density. A reversal curve may also be considered a print curve when the horizontal axis refers to exposure given the original from which the print was made.**

# LABORATORY

## HOW TO TURN IN EXPOSED FILM TO LAB

Although unloading, canning and labeling exposed original reversal color or negative color camera film for processing is a simple procedure, it is amazing how many cameramen fail to follow the few simple rules that apply to this important task.

Exposed daylight loading spools should be removed from the camera in subdued light. It is a little known fact that there is greater chance of *edge fogging* daylight loading spools of film when they are *removed* from the camera than when they are inserted. Daylight spools are loaded at the factory with an oscillating side-to-side motion so that the film edge is positioned against *both sides* of the spool. This prevents light from penetrating more than a layer or two of film. However, cameras layer film onto the take-up spool in a straight line. It is possible, therefore, that the film may be positioned against *only one side* of the spool — which would allow light to penetrate the depth of the roll and edge fog the exposed film.

If a great number of daylight loading spools are used on a job, particularly a news, documentary or cinema verité assignment where filming is fast and furious, it is smart to temporarily tape the cans *across*, rather than around the outer diameter. This will prevent picking up an exposed roll and rethreading it in the camera. The cans may be normally taped later for submission to the lab for processing.

Laboratory loads of film should be removed from the magazine only in a photographic black bag or a photographic darkroom. If a darkroom is used moisten a finger with the tongue and wet the end of the film so that it will stick to the roll. (Do *not* moisten the film directly with the tongue — modern color film's exotic chemistry may be harmful!) Or, use a piece of tape, or the paper band supplied with daylight load film to prevent the edge of the roll from unwinding and dangling on the floor when it is removed from the bag. If a test roll is placed in the same can, the corners of the film end should be folded back so that the roll may be easily identified in the dark. Do not cut the black bag if it is too large. Fold the bag so that it may be salvaged and reused. Labs are always short of black bags — so they should not be destroyed by mutilating them. Use only cloth tape to seal the can. Do not use paper tape because it may split and require a knife and a good deal of time to open the can. Fold the end of the tape under so that the lab man can find it quickly. All of these procedures may seem unimportant to a cameraman or assistant but they are tremendous time savers to lab personnel who must unpack the film and pre-

pare it for processing. Labs base their charges on the time required to put the film through. Anything that can expedite the film through the lab saves time and money.

Exposed color film should be processed as soon as possible. Delay in processing can cause image deterioration. The different color layers deteriorate at different rates, so *color* is also *unbalanced* by delayed processing. The practice of storing *exposed out-takes,* to save a few pennies processing charge, and then a few weeks later turning them in for processing — when the film editor or producer does not like the printed take — is deplorable! The delay in processing, and storing at ordinary room temperature and humidity, will show up in poor color balance and cause the lab great difficulty in matching the color quality of the overall sequence. In some cases, if storage is over a long period, it is impossible to match the color quality of the stored scene to the rest of the sequence.

Label all film cans properly with film name, and *both* emulsion number *and* batch number. Example: Ektachrome Commercial, 7252-166. The batch number is important because the lab may have information on a particular emulsion batch, such as special filtering required in printing, and they can give the film the special handling it requires if they know the batch number. List the film's proper length — do not guess! Note how many rolls in each can, if there are more than a single roll, and list the length of each. Do *not* pack different type films or different emulsion batch numbers in the same can. Pack film to be "pushed" in a separate can with clear instructions for the number of stops that the film should be *push-processed.*

Camera cards should be carefully filled out and clearly written so that the lab can identify the production company, roll number, date and other pertinent information. The director's preferred take is *circled.* A square is drawn around a "hold" take that the directtor finds acceptable and wishes to see. Labs will print circled and squared takes only — unless instructed to print the entire roll. If individual takes are not slated the roll number should be slated at the head of the roll and the lab instructed to print the entire roll. If a great percentage of the scenes shot are to be printed it is probably less expensive, and certainly faster, to print the whole roll, rather than to break it down and remove the few scenes that are not desired. Camera cards should be taped to the can containing that particular roll, or rolls, of film.

A purchase order should accompany the exposed film so that the lab is provided with complete instructions for processing, printing, edge numbering, storing or returning the film and print — and any other pertinent information. The lab should be informed whether to *process only,* in the case of original reversal color

camera film, or *process* and make a *one-light work print*. Some production companies wish to visually inspect (not project!) original reversal color film and break it down so that the desired scenes are spliced on one roll and re-submitted to the lab for printing. Negative color film is generally processed and a one-light color "daily" print of the desired takes ordered. In ordering one-light color dailies it is important to state whether the chosen light number is either "center" or the lab's choice. The entire roll may be slightly under or overexposed, in which case the lab can better choose the one-light that will produce the best possible print. A one-light color daily may also be ordered with a *single overall color correction,* if desired. This would be helpful, for example, if the entire roll were shot under fluorescent illumination. The director of photography on a feature picture or a television show generally sets up camera and lab tests to find the best single light setting for the entire production. Or, several one-light settings may be chosen for printing studio and location scenes, or day and night scenes, or for special color effects.

The lab may be instructed to process and "ink edge number" the original film with a particular code letter symbol. (Different code letters will help to instantly identify a roll of film in editing. This is very helpful if several productions are being edited simultaneously, or if different types of films, such as Ektachrome Commercial and Ektachrome EF, should be separated for a particular reason.)

Inform the lab whether to store the original and return the work print only — or return both. Negative color is generally stored in the lab's vaults until required for editing. Reversal color originals are either stored by the lab or returned to the customer, as requested.

Many labs cannot process original Ektachrome Commercial or Ektachrome EF — they are equipped to handle work prints only. Such labs generally supply their customers with special labels that may be placed on the original film so that the cameramen can submit the film directly to the lab processing the original. The original film processing lab will then return the original to the work print lab and bill them. This saves time and simplifies billing.

Find out the lab's closing time so that exposed film is delivered in plenty of time for processing that night and the producer can be assured of a work print the next day. Cooperate with the lab — don't arrive at five minutes to closing time and get into a long discussion or argument on how the order should be handled! Make arrangements ahead of time if special service is required. Get acquainted with the lab, learn their schedule, supply them with properly filled out camera cards and purchase orders. Write clear, concise instructions, particularly if the film requires special handling.

## COLOR FILM PROCESSING

All color films are processed on continuous machines according to the film manufacturer's specifications. Circulating solutions under rigid temperature control develop the film for a precise length of time that produces the required gamma for that particular film stock. All cameramen must, therefore, "shoot for the lab" because individual consideration cannot be given a particular roll of film. The only compensation the lab normally makes is to "push process" certain color film emulsions by extending development time to increase density of underexposed scenes. There is a slight extra charge for this service cause it requires a separate run and takes longer to process the film. (SEE: *Push Processing*)

Any deviation from normal processing requires special arrangement with the lab. Processing labs are very cooperative in aiding the cameraman to achieve a special color effect or a particular "look" for a period picture. Most effects can be produced when the original is printed. If the original camera negative or reversal color film must be given special development it will be necessary to arrange for both camera and lab tests that will determine how the film should be exposed and processed.

## COLOR FILM PRINTING

System-films, such as Eastman Color Negative, Eastman Ektachrome Commercial and similar original camera films intended for the production of release prints, may be corrected or otherwise altered when printed onto intermediate film stocks or color positive films. The lab can make *two types* of printer correction: (1) a *density correction* when the original is under or overexposed (too light or too dark) and (2) a *color correction* when the original is out of color balance (the three color layers have unequal densities). The original may be normally exposed and color correct, and printed lighter or darker or altered in color values for a special effect. Printing the original film, therefore, not only provides the cameraman with a means for *correcting* the original but also a method for *creating* overall color effects.

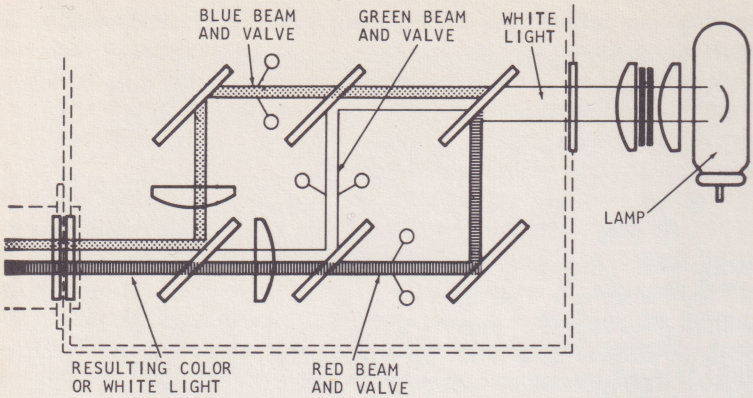
DENSITY CORRECTION. The density of an original film is corrected by employing more or less light than normal when the film is printed. The higher the light number the greater the light intensity. An original *reversal* camera film is *darker* (has greater than normal density) when it is *underexposed*. A higher than normal printer light number must be used to produce a print with normal density. *Reversal* film is *lighter* (has less than normal density) when it is *overexposed*. Conversely, it requires a lower than normal light number to produce a normal density print. A vastly underexposed original reversal film contains little or no detail, so

there is very little image available for printing, regardless of how much the printer light is increased. Vast overexposure, on the other hand, *burns out* the highlights so there is little or nothing, often blank film (referred to as a "hole" in the film), left to print. Printing such film darker simply results in a gray mass (neutral density) with little or no highlight detail.

*Negative* film has values that are the *reverse* of the original scene: shadows are thin and highlights are dense. An *underexposed negative* is *thinner* (has less density) than a normally exposed negative. It must be printed on a lower than normal light number to produce a normal density print. An *overexposed negative* is *heavier* (has greater density) than a normally exposed negative. It must be printed on a higher than normal light number to produce a normal density print. Since negative color films are developed to a lower gamma than reversal color they may be corrected over a wider exposure range. However, a very thin, greatly underexposed negative will produce a grayish looking print because so little light must be used to expose the print stock that a true black density cannot be produced. A very heavy, greatly overexposed negative will produce a grainy looking print because the negative highlights are *blocked up* (too dense) and possess increased grain — printing simply reproduces this grain effect.

COLOR CORRECTION. Negative and reversal color films are now generally printed on *additive* printers in which the light from a *single printing lamp* is *split* into *red, green* and *blue* color beams by selectively reflecting and transmitting dichroic mirrors. The printer is equipped with *three light valves* (one each for red, green and blue components of the light beam). Each light valve has a variable gap between the blades to control the *intensity* of the light. The red, green and blue components of the light are *recombined* into a *single beam* which exposes the film. This method of printing permits controlling *both* the *intensity* and *color* of the light used to expose the *individual color layers* of the film stock. The printer's light valves are actuated by a punched tape reader that decodes the signals and places the information "in memory" so that it is ready for an instantaneous light change for the next scene.

Additive printers permit the most efficient use of the light source and allow altering the *density* and *color balance* of the original film when it is printed, in almost any manner desired. When *all three valves* are changed by the *same* amount the *color* of the light will remain the *same* — while the *intensity* of the light is *changed*. If the gap in *one valve is increased* and *reduced in another* it is possible to *change the color* of the light — while the *intensity* remains the *same*.




**The Bell & Howell Series "C" printer operates on the additive color principle. The light from a single printing lamp is split into red, green and blue color beams by selectively reflecting and transmitting dichroic mirrors.**

Additive printers are calibrated in 50 points, or printer light numbers. Each increment, or step, is equal in intensity. The difference in intensity *between* each light number is equal to .025 log E (which is similar to .025 neutral density). This is equal to 1/12th of a lens stop (.025 X 12 = .3 or ND 0.3). The cameraman can better understand printer light numbers and correlate them with exposure by comparing their density values with Neutral Density filters. Note that these values, however, apply only to the printer. The correlation between printer light values and camera exposure will be explained later on as they apply to both reversal color and negative color films.

The following list shows how light numbers correspond to exposure as light numbers are changed up or down from center.

| Light Number Change from Center | Density (ND) Change | Exposure Equivalent (Stops) |
|---|---|---|
| 1 | .025 | 1/12 |
| 2 | .05 | 2/12 = 1/6 |
| 4 | .10 | 4/12 = 2/6 = 1/3 |
| 6 | .15 | 6/12 = 3/6 = 1/2 |
| 8 | .20 | 8/12 = 4/6 = 2/3 |
| 10 | .25 | 10/12 = 5/6 |
| 12 | .30 | 12/12 = 1 |
| 24 | .60 | 24/12 = 2 |

Center of the printer scale would normally be 25, that is normally exposed camera film, negative or reversal, should print on

light number 25 to produce a normal print. This would be expressed as 25-25-25, or the light number of the red, green and blue components, if all three layers of the original film were equally exposed. It is important to check with the lab to properly understand these numbers because labs differ in the *order* of listing the colors. Most labs employ RGB (red, green, blue) in spectrum order. However, other labs use variations based on the order of the colors on the color wheel. This may result in either of the following orders: BGR or GRB. It is wise, therefore, to find out how the lab lists the order of their color timing, so that when prints are ordered that require a particular color correction, the cameraman, or film editor, uses the same color order in referring to the light numbers as the lab. Or, to make certain, list *both* the light numbers *and* the initials of the colors: 31-22-33 (RGB).

Unfortunately, all labs do not use 25 as the center of the printer scale because printer light settings do not refer to absolute values, but only to proportions relative to an arbitrary range of light values set for a given film stock at a particular lab. Color and intensity of printing lights are regulated by adjusting the printer "trims" which are separate from the light valves. Trims are adjusted to compensate for different print stocks and variations in emulsion batches and processing, so that a given scene printed at a given light number will always produce the same results. No industry-wide standards exist for setting printer trims and defining the range of printer values for a given print stock. Therefore, a scene printed at a particular series of light numbers by one lab will not necessarily produce the same result when printed with the same numbers by a different lab. There may be a difference of as much as 10 points between labs. A scene printed at 25-25-25 by one lab may require 30-27-22 at another lab to produce the same print. This is the reason that after an original film is timed and a tape is punched it cannot be given to another lab and printed without making a new tape.

If the edited picture is altered in any manner — scenes cut, scenes transposed, scenes pulled, etc., — the lab will have to re-time the film and punch a new tape. If a roll of edited original film is removed from the lab and *not* altered in any manner, the lab should be notified when it is returned for a new print that it does *not* need to be re-timed. Lack of such notification can prove costly because the lab will automatically re-time the film unless instructed otherwise.

The RGB triple set of light numbers are divided by three to find the *average number* — which indicates *density* only. Although density may be normal (for example, 25-20-30 = 75 ÷ 3 = 25), something may have been wrong with the color balance of the light used to expose the original scene. Under controlled studio

conditions it is possible to print "straight across" with all three light numbers the same. However, slight differences are perfectly acceptable. Film emulsions or lab processing may account for small differences, so that a layer of the film may be 1 light number (.025) or 2 light numbers (.05) off. Or, the lab timer may prefer slightly cooler or warmer scenes. Judging color values is a purely subjective experience and depends on individual preferences. Timing is generally based on the appearance of flesh tones. The audience has no way of knowing the actual color of player's costumes, furniture, backgrounds — but they know how a flesh tone *should look!* Not necessarily the way the particular player's flesh tones actually appear in real life but the way an *average* flesh tone looks. Most White and Black people prefer flesh tones that are actually a bit warmer (more yellow) than in real life. Orientals, or members of the yellow race, on the other hand, prefer cooler bluish flesh tones. Television color consultants speak of "pleasing color" rather than perfect color — and flesh tones on television generally are transmitted with additional yellow — or warmer than normal. The director of photography, the art director or someone with good color sense representing the producer, should sit in with the lab timer when the first color answer print is evaluated for approval or re-timing.

The cameraman should be concerned when printer light numbers are widely separated. This occurs when scenes are filmed with fluorescent light which does not have a continuous spectrum and is generally *minus red* — which makes the picture appear greenish. The light numbers for a fluorescent illuminated scene shot on reversal film could be 40-15-25 (RGB), for example. Since the original film is minus red it requires a higher light number for red to replace the density missing in that layer, and a lower light number for green, since it is overly green, to produce a properly color balanced print.

The lab should be instructed *not* to correct special color effects. Colored gels may be used in front of the lights for a firelight, candlelight or kerosene lamp effect; or scenes may begin normally and move into a color lighted area, or vary in color effect from a yellowish candlelighted room into a bluish moonlighted street. Camera cards should be marked "no color correction" on such scenes and the lab liaison man, if one is assigned to the production, should be instructed to follow up the order to be certain that color effects are *not corrected!* Generally, if a one-light daily color print is made of such scenes and they appear in the middle of the roll they will not be corrected. However, an entire roll of such effects may be given an overall color correction if the lab is not notified otherwise.

## PRINTER LIGHT NUMBERS CORRELATED WITH EXPOSURE

Printer light numbers may be translated into camera exposure in stops, or fractions of a stop, so that the cameraman can tell if he is exposing normally or is under or overexposed.

REVERSAL COLOR. Ektachrome Commercial's 1.15 gamma equals 12 printer points, or approximately 1 stop (.025 X 12 = 0.3 log E, or ND 0.3, or 1 stop). If Ektachrome is overexposed 1 stop, it is too thin because it is *minus* .30 density. The missing density may be provided in printing by adding .30 density (similar to combining the original scene with ND 0.3). This is accomplished by printing 12 printer points *lower* than normal. In other words 1 stop *less* light is used in *printing* to make up for the 1 stop *more* light used on the *original exposure!* If Ektachrome is underexposed 1 stop, it is too dense because is is *plus* .30 density. To decrease the additional density in printing it will be necessary to print the scene 12 printer points *higher* than normal. The printing light exposure is thus increased 1 stop to make up for the original underexposure. Density correction can be easily comprehended if thought of in this manner — density is either *too much or too little* in the *original* and an *opposite correction* is made in printing to *add or subtract density* and thus produce a normal density print. (Note: In order to compute over or underexposure in lens stops it is necessary to know which light number the particular lab is using as their center light. The number of printer points above or below their center light number may then be translated into lens stops, or portions of a stop.)

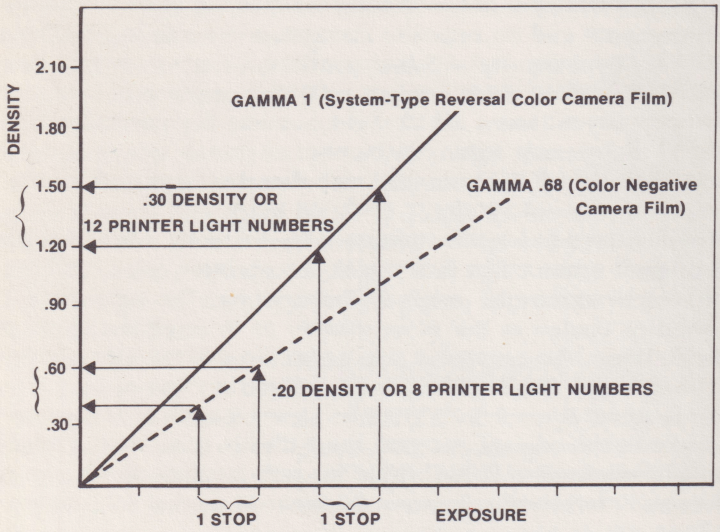
Color correction for color reversal film is directly related because the original camera film is a positive, so printer color correction is the same as for the original photography. The color may be warmed or cooled in the same manner as in original camera exposure. When the original is too warm the printer light numbers will read higher on blue because a greater amount of blue filtering is required to cool the picture and bring it back to normal color balance. If the original reversal color film is cool, or too bluish, the light numbers will be higher for red, because the scene requires more red filtering to warm the scene to normal color balance.

NEGATIVE COLOR. Before explaining negative color film timing it should be emphasized that printer light numbers are the same for both negative color and reversal color films. Eastman Color Negative has a gamma of .68, however, which is lower than Eastman Ektachrome Commercial's 1.15. Therefore, it requires fewer light numbers for similar print correction because there is *less density change* in the negative than in the reversal film for a similar amount of under or overexposure.

Eastman Color Negative .68 gamma is approximately two-thirds of Ektachrome Commercial's 1.15 so it requires only .20 density to equal 1 stop. If negative color is under or overexposed 1 stop it therefore requires only 8 printer points lower or higher than normal to make the correction (.025 X 8 = 0.2 log E, or ND 0.2, or 2/3 stop density). For practical purposes, however, most labs consider 10 points equal to 1 stop because of losses due to flare in printing and other imperfections in the system. Therefore, 10 printer points above or below the normal middle light setting would indicate that the negative is over or underexposed 1 stop; 5 printer points would indicate 1/2 stop, etc.

A color print from a color negative may be visually judged in the same manner as a print from a reversal original film. It is warm or cool in the same sense. But, lab personnel must make an *opposite* color correction when printing a color negative onto color positive stock.

**COMPARISON OF NEGATIVE & REVERSAL PRINTER CORRECTION**




**A 1 stop difference in original photography produces a .20 density difference with negative color film and a .30 density difference with reversal color film. Negative, therefore, requires 8 printer points to correct 1 stop over or underexposure, while reversal requires 12 printer points for a similar correction.**

## PRINTER VS. CAMERA

The cameraman should understand that light numbers relate *only* to the way the *printer exposes the print stock* — *not* the way the *camera exposes the original film*. Although 12 printer points equal .3 log E, or ND 0.3 (or the logarithm of 2, which is 1 stop, since exposure doubles with each stop, or .3) this does not imply that 1 stop exposure on the printer produces the same density on the print as 1 stop in the camera — over *the entire range!* The H and D curve would have to be a straight line and extend over an infinite range and have a gamma of 1 in order for this to be true.

Printer light numbers and original film exposure are closey related *only* on the *straight line portion* of the H and D curve, where gamma is plotted. The *toe* (shadows) and *shoulder* (highlights) are *compressed,* so there is *less density difference* on those portions of the curve for 1 stop exposure. For example, if the 18% grey card is correctly exposed it will print center scale. A 1/2 stop over or under exposure of the card on Ektachrome Commercial would require 6 points higher or lower (.15 log E = 1/2 stop) to print the card with normal density. This would be equivalent to 1/2 stop over or underexposure of the original scene. However, if the scene were over or underexposed 2 stops it would require a theoretical 24 points (24 X .025 = .60, or ND 0.6, or 2 stops) for normal density correction — *providing* the H and D curve of the original film extended in *a straight line*, rather than having a *sloping* toe and shoulder. A 2 stop printer correction, in this instance, would *not* be necessary because the camera exposure is *not* on the straight line portion of the H and D curve. It would, therefore, require *less* than 2 stops correction on the original film to obtain a normally exposed scene. A study of the H and D curve will show why this is true. The *density* produced by each stop on the *straight line* portion of the curve is the *same* — but the *density* produced by each stop on the *toe* and *shoulder* of the curve is *less* because *these areas are compressed.*

DENSITY AND COLOR CORRECTION COMBINED. Color correction also affects density correction, so they must be considered together. Think of each layer as being exposed to its own color only. If the light balance used to expose the original film *matches* the film balance each layer will receive an *equal* light intensity, or equal exposure. All three layers will print *straight across*, such as 25-25-25. When the red, green and blue of the original light source are *not equal*, however, such as in filming with fluorescent illumination, each layer will receive a *different* exposure so it will have a different density. In the case of reversal color film this could result in printing red at 36 (because fluorescent light is *minus red*), green at 9 (because fluorescent is *plus green*) and

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blue at 30. In other words, the color that is low in density (red) is printed higher — and the color that is high in density (green) is printed lower, to bring the color layers back into balance on the print for a more or less normal color effect. Fluorescent illumination can rarely be corrected to appear as if filmed with color correct 3200 K illumination. A satisfactory correction can generally be made, however, particularly if the cameraman used the recommended filters over the camera lens and/or lights. Correcting the original camera film will then provide the lab with a greater range of color correction because the three color layers will be a little closer in density. (See: *Fluorescent Illumination,* and also *Rosco Fluorescent Daylight Media*)

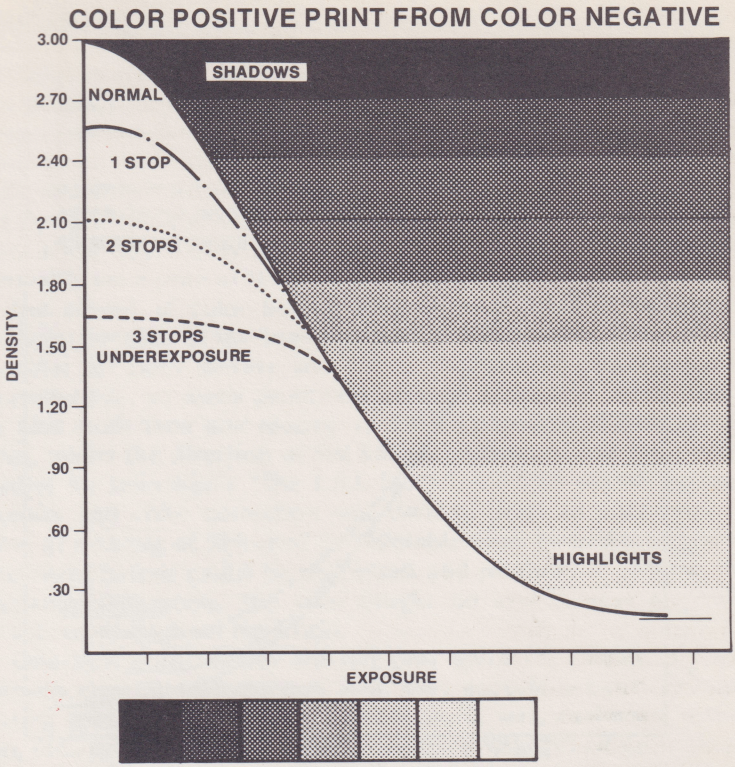
If the above example, 36-9-30, is averaged it will equal 25 (36 + 9 + 30 = 75 ÷ 3 = 25). Overall three layer density tells the cameraman that his exposure is normal, but the three light numbers tell the true story: the original color film is out-of-color-balance.

On the other hand, scenes may be color correct but over or underexposed, if they printed at 20-20-20 or 40-40-40. Averaging the printer light number thus provides the cameraman with information on *exposure,* or *overall density only.* The red-green-blue relationship of all three printer light numbers provides the complete data on color balance.

For example, with *reversal* color film the *higher* the light number (for a particular layer) the *greater* the *deficiency* of that portion of the light spectrum used to expose the film. Using RGB 36-9-30, the cameraman is informed that the light source underexposed the red layer, vastly overexposed the green layer, and slightly underexposed the blue layer. To properly color balance the print additional red light is required, so a higher red printer number is needed. Green must be removed from the original so a lower green printer number is required. Blue requires only slight color correction since it is only slightly underexposed.

The opposite is true with negative color film because the *colors are reversed.* Fluorescent illumination could result in printing RGB 17-35-23, which informs the cameraman that the illumination, and negative density, is deficient in red — because it is *underexposed* and requires a *lower* light number for correction. The green layer requires a higher number so it is overexposed which means that the original light source was plus green. Blue is approximately normal so it prints close to center scale.

In effect, whether dealing with reversal or negative color, the lab is simply *adding or subtracting density in each color layer* of the color print stock — to correct for too little or too much density on the original film, due to exposure errors and/or the fact that the light used to expose the original was out of color balance.

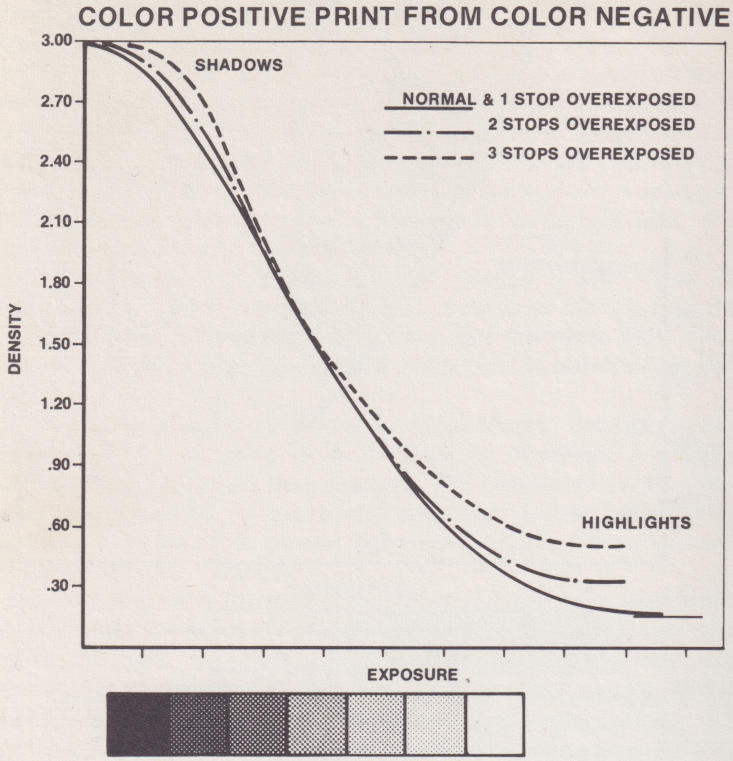



**Curves depicting color prints made from correctly exposed color negative and also from underexposed color negatives corrected in printing. Highlights will print about normal. Shadows will have no density greater than the particular curve indicates for that amount of underexposure.**

If light number 25 is center scale for the lab, the negative color should print in the 20's and 30's for best print quality. Under light 20 (underexposed) and over light 40 (overexposed) should be cause for concern. With the same 25 center scale, reversal original films should print between 20 and 30 for best results. Under light 20 (overexposed) and over light 35 (underexposed) would call for greater accuracy in exposure for best results. Note that the center of the scale for a lab may be other than 25, so add or subtract the necessary factor for the particular center scale in use to judge original negative or reversal exposure.

Remember that lab corrections are limited to approximately two stops error in exposure. Such heavy corrections, however, do not necessarily produce a good quality print. The best print will always be made from the finest original, whether negative

or reversal. The closer to normal density and color balance the original film — the finer quality the resulting color print.




**Curves depicting color prints from correctly exposed color negative and also from overexposed color negatives corrected in printing. Note that one stop overexposure does not differ perceptibly from correct exposure. Also note that highlights become grayed in print from greater overexposure.**

All H and D curves in the Workbook are for the use of cameramen, not lab personnel. All graphs depicting a *single* curve may be considered a single layer of the color film, generally the red record, or a composite or average of all three color layers. DENSITY always *increases going up* on the *vertical* axis of the graphs. EXPOSURE always *increases from left to right* on the *horizontal* axis of the graphs. Calibration or "tick" marks are one stop (.30 ND) apart — moving left or right *one* space *halves* or *doubles exposure*. Note that Exposure (horizontal axis) readings refer to the *luminance range of the original scene*.

## ONE-LIGHT COLOR DAILIES

Daily prints or "dailies" (sometimes referred to as "rushes") are work prints made from the original negative, or reversal, processed during the night following exposure and printed for evaluation the next day. Daily print service is generally available only in motion picture production centers but with the advent of jet flying a cameraman shooting almost anywhere in the world is only a few hours away from a color film processing lab, so he can generally see a print of his work within a few days.

The advent of color filming introduced a delay in daily print delivery because of the time involved in timing each scene of the original for both density and color. The cost involved was also considerable, so many producers ordered black and white dailies to save both time and money. In 1965 Consolidated Film Industries, under the direction of Sid Solow, introduced one-light color dailies for television's "The F.B.I. Story." A single overall average density and color correction was used to print an entire roll of film, at a saving of 50% and considerable time. Negative turned in the night before could be processed and printed for viewing the following afternoon. The idea caught on and is now generally practiced throughout the world.

One-light color dailies are not only good for morale of both camera crew and production staff, they provide a basis for evaluating color values, lighting, camera work, sets, costumes, make-up, etc., on a day-to-day basis. If anything changes or goes wrong it is immediately apparent and may be corrected. Watching black and white prints of color original material is very depressing because color contrast is missing. A scene flatly lighted that may be beautiful in color may appear in black and white as a flat grayish mass because the tonal values do not provide the dimensional qualities, separation and contrast of the scene in color. A color print, even though not perfectly timed, will look very close to what was filmed and provide a good indication of how the final release print will appear. The cameraman will know immediately whether or not each scene will print satisfactorily.

Color dailies are a great aid in editing because the film editor may judge color changes from scene to scene and can avoid splicing scenes that may result in a harsh color difference. Actors, producer, director, and other non-technical people involved in the production may also better evaluate their work because it is representative of the original scene. It is not an abstract black and white suggestion that must be interpreted into color values that are difficult, if not impossible, to imagine.

The director of photography, however, benefits most from color dailies because he can use the one-light print as a standard to

shoot to. He will know immediately if color balance or exposure is suddenly off, or if a particular lens produces a color cast because it has a different coating or construction. If several cameras and lenses are used any mis-matches will be noted. Camerawork can thus become more consistent on a day-to-day basis because the cameraman is shooting for the center of the scale and knows whether or not he is hitting it.

One-light color dailies have a few disadvantages that are far outweighed by their advantages. They should be noted, however, because they are important to the cameraman's attitude and approach to his work. A low-key scene, a day-for-night sequence or a special color effect may require under or overexposure of the original negative and printing up or down, for the best possible release print. But, the cameraman shooting for a one-light color print will be influenced to *avoid* such techniques, particularly if it involves only a scene or two in the middle of a roll because it will look bad printed on a center light. This type of situation can be handled, however, by separating such scenes and asking the lab to choose a light that is best for that particular roll, rather than the average light being used for the overall production.

One-light dailies are not necessarily printed in the middle of the scale or on the same light for everyone. Each company's negative is examined and analyzed, generally with a Hazeltine or Eastman color film electronic timer, and the *best* light chosen for that particular production. The first batch of dailies is generally viewed with the cameraman to find out if he prefers a different light or color correction. Variations in the projection light intensity at a particular studio may require a slightly lighter or darker print, or the cameraman may prefer a warmer or colder flesh tone than the lab chooses. Many other variables enter into the choice of the one-light chosen to print dailies: the characteristics of the particular batch of color film emulsion, film storage conditions, lights, filters, difference between zoom and conventional lenses, lens coatings, even the environment in which the film is shot — the desert heat or the winter cold may affect exposure and color balance. Thus the one-light chosen may vary widely from one assignment to another. Different one-light positions may also be chosen for studio and location filming, or for day and night scenes, or even for different cameras employed to shoot a multi-camera television show. Therefore, one-light dailies for a given production may be printed on three or four or more different lights which may vary over a wide range.

Reports indicating the light used to print the dailies are not generally included with the film, although they are available if requested. Some labs will report the average number for the RGB lights used, or the value for the red light, as an indication of neg-

ative density. A spread of even 10 to 12 points between the RGB numbers is not unusual, depending on how the particular lab sets its printer trims. The spread between light numbers is important if the cameraman is striving for a particular color effect and the lab requires a different exposure or color balance to heighten the effect later in the final print. Shooting with color gels on the lights, for instance, to add to a fire effect may cause the lab difficulty later if the effect is too much and must be corrected toward normal. The red layer may be overexposed and the green and blue layer have very little density so the lab has little room for correction. The cameraman should be more concerned with "local color, such as a colored kicker on the side of a face, or a colored effect on a wall, rather than with overall color — which the lab can introduce in printing. Almost any amount of blue, for example, can be given a night scene — there is little need for the cameraman to employ blue gels on the lights. However, if the cameraman wishes the players to be "clean" (that is color correct flesh tones) and the background blue — it would be best to use blue gels on the background lights only, or to shoot with arc lights equipped with white flame carbons which will reproduce bluish when filming with a 3200 K tungsten light balance.

Cameramen should not request that their dailies be printed "in the middle" of the printer light scale. The middle of the scale can mean one of two things: printing in the middle for that particular lab, such as 25-25-25 or whatever series of numbers are used for the particular printer trims), or printing to achieve a mid-density with whatever corrections are required to produce a proper color balance. It is far better to let the lab know the mood or color effect desired and let them choose the best light number.

Labs differ as to the best means of judging density and color. Some labs prefer that the cameraman shoot a gray scale fully exposed with light of proper color temperature, preferably at the beginning of the roll. This furnishes the timer the means for interpreting the negative, or reversal, and judging exposure and color balance. A perfectly exposed series of gray steps and neutral 18% gray will indicate normal exposure and good color balance. There are labs, however, that do not wish a gray scale because it will be ignored as of little use. They do not consider it the best means for determining the printer light numbers. Check with the lab and find out their preference.

One-light color dailies have their limitations but they are the best all around choice for everyone concerned. They are a compromise and the cameraman striving for a special effect now and then may not have his work look its best — and may find it difficult to make the director or producer understand that the effect will be correct in the release prints. All production personnel must

understand that one-light color dailies are a time and money compromise and that a great deal of density and color corrections are possible later. Changes from shot to shot within a sequence are sometimes difficult to explain, particularly when different lighting is employed for close-ups than for long shots.

Timed dailies may be ordered, of course, if the budget and the producer permit, but they are an unheard of luxury! If special color effects are involved in a production, tests should be filmed. The cameraman and lab timer should work out the best method for timing that will deliver good quality one-light color dailies and still permit the lab the greatest possible color correction later when release prints are made.

## CONCLUSION

Although the processing lab can produce amazingly good color prints from badly exposed original color film, the cameraman should not use the lab as a crutch to cover mistakes in exposure or light balance. The lab cannot work miracles — they cannot pull images out of thin air and place them on the film! Only the cameraman can produce images. The lab can process and print only the images they are given to work with. No image no picture — its as simple as that. The lab can, however, provide the cameraman with a wide range of overall color effects — providing the original color is such that it permits such manipulation. Remember that the finest release prints will *always* be made from the finest original film.

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## ACL HANDBOOK

RECOMMENDED STANDARDS AND PROCEDURES FOR MOTION PICTURE LABORATORY SERVICES, published by the *Association of Cinema Laboratories,* is an excellent Handbook for acquainting the filmmaker with lab processing terminology, preprint preparation and procedures, which, through the efforts of ACL, have become standard in the motion picture industry. Text, diagrams and printing flow-charts cover 16mm and 35mm color and black and white films for theatrical, nontheatrical and television use. Preparation of original A and B rolls is thoroughly covered. The Handbook also includes the American Standard "Nomenclature for Motion Picture Film Used in Studios and Processing Laboratories" (PH22.56a-1964).

A copy of the Handbook may be obtained for $1.00 plus mailing charges from an ACL member laboratory, or write:

The Association of Cinema Laboratories, Inc.
1925 K Street, N.W.
Washington, D. C. 20006

## PUSH PROCESSING

Push processing, also referred to as "forced" or "boosted" processing, *extends the development time* of color film to increase its *effective* Exposure Index. Film manufacturers rate color camera films on the basis of practical tests that produce optimum quality. Color balance, contrast and grain structure are best when the film is normally exposed and normally processed. Any variation in processing, such as increasing development time, results in characterstic changes that tend generally to lower image quality. These changes depend upon whether the camera film is a negative or reversal emulsion.

There are photographic situations where the cameraman must sacrifice top color quality to get the picture. News, documentary and cinema verité films must often be photographed under very poor lighting conditions. Interiors and night exteriors, particularly on location, must often be filmed under low light levels. Light intensity is also a factor at high camera frame rates, or when zoom or telephoto lenses with relative small apertures must be employed. Sufficient power and lighting equipment may not be available for illuminating large areas, particularly outdoors, or economy may dictate less power and lamps for studio filming, or the director may desire that the actors be kept "cool" by working with a lower light level. These, plus pictorial reasons described later, may require that the color film be push processed.

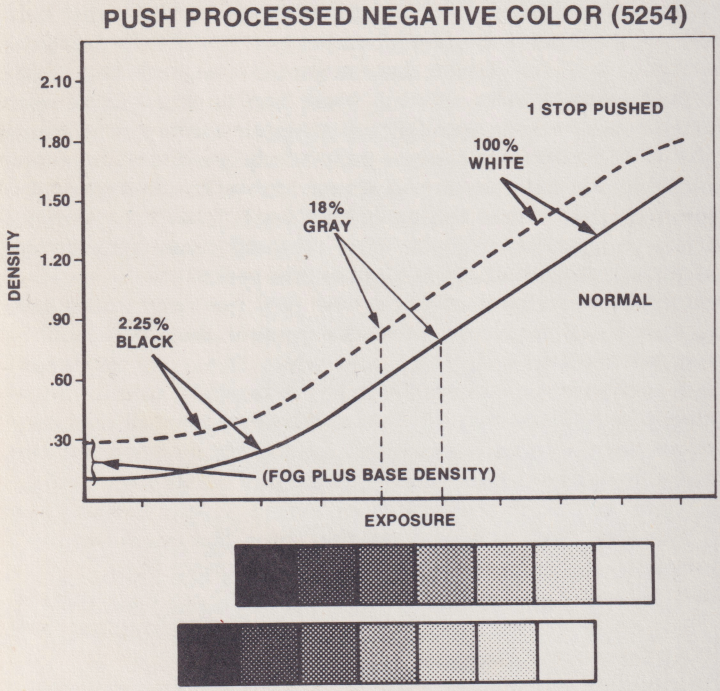
Generalities describing characteristic film behavior under certain conditions of exposure and development that were true in the past, particularly with black and white films, are no longer true with today's color camera films. For example, it can no longer be stated categorically that *all films increase in gamma and contrast when development is extended*. Each particular reversal and negative color camera film must be evaluated on its own particular response to various conditions of exposure and development.

The following data is based on the color film manufacturer's recommendations for pushing their particular camera films.

Both GAF and Agfa-Gevaert recommend pushing their reversal color films no more than one stop, thus effectively doubling their respective Exposure Indexes.

At this writing (November 1972) Eastman does *not* recommend pushing their newly introduced Color Negative II Film (5247 and 7247). Further testing and practical filming is required before a thorough working knowledge of this new emulsion is acquired. The new color stock is processed at a higher temperature for a shorter length of time and with a newly devised chemical process. Cinematographers who wish to experiment for pictorial reasons may attempt pushing to "see what happens" but a test should be filmed before attempting production work.

Eastman Color Negative Film now in use (5254 and 7254) gains no more than two-thirds of a stop in apparent speed, regardless of how long processing is extended. Longer processing increases the fog density and thus the overall density, so the scene will print on a higher light number. This may help the lab when push-processed scenes are inter-cut with normally exposed and normally processed footage because the light numbers are closer together and light changes may be made *between* frames. The film may be pushed two stops to increase this fog density but unless a higher light number is required there is no point in pushing color negative more than one stop because additional processing time will result in greater loss of image quality with no real gain in actual film speed.




**Push processing negative color one stop increases shadow density but middle tones and highlights remain almost the same.**

If Eastman Color Negative is *underexposed one stop* under studio conditions where the lighting is balanced (highlights and shadow areas are exposed well within the luminance range of the film) and then *push processed one stop* in development, there will be an increase in shadow density, middle tones and highlights

will remain the same, gamma remains the same and there will be some color shift. The color print will look much the same as a print from a normally exposed, normally developed, color negative except that it will be slightly grainier and shadows will be grayish, rather than black — so overall *contrast is decreased.*

When Eastman Color Negative is *underexposed* under *unbalanced lighting* conditions, such as night exteriors that include dim shadow areas and brightly illuminated store windows, signs, street lamps, etc., and then pushed processed, the resulting print will generally display increased contrast. This occurs because the highlights will be burned out since they are generally overexposed *and* overdeveloped. Exposure for such scenes is generally for the shadows with no thought given the bright highlights and light sources in the scene. A normal Exposure Index of ASA 100 (21 DIN) requires only 50 footcandles (500 lux) of incident light for exposure at T-2. This will generally be found in the vicinity of such brightly illuminated areas. A spot meter reading of the signs and light sources will show that they will be well exposed at this lens aperture. However, when the film is given a rating of ASA 200 (24 DIN) and pushed one stop, or ASA 400 (27 DIN) and pushed two stops, the highlighted areas and light sources will definitely block up and appear burned out in the print.

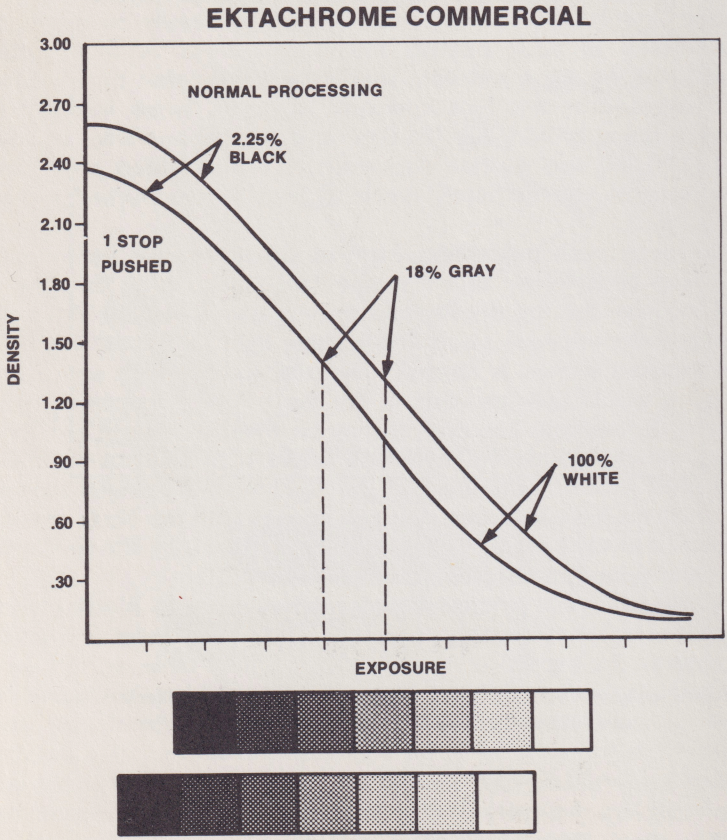
However, push processing Eastman Color Negatve more than one stop is generally valid for one-light color dailies because it will increase the fog density and the negative will print closer to center scale and look good at the same light as the other normally exposed scenes. A normally exposed and normally processed negative would look too dark at the same light. If extensive night filming is required, however, it may be wiser to expose the long shots, which include the signs and bright light sources, normally and push process only the dim low light level shadowed scenes. Or, push no more than one stop and arrange with the lab to choose a lower one-light number for the particular batch of film involved. This may permit making a better release print later.

A reversal color original film is quite similar to a color print from a color negative. Push processing a reversal color film tends to *destroy* the highlights — they become more clear or burn out. Reversal is first developed to a negative, which is chemically bleached out. The *remaining* silver is then redeveloped and coupled to form the basis for the final dye image. After the dye image is formed all of the silver is bleached out, so the color image is all dye. Reversal has the benefit of finer grain because the larger, more sensitive silver grains, are exposed in the camera and later bleached out — so that the remaining finer grains are coupled. Therefore, the greater the exposure and/or development

given a reversal film, the more silver is "lost" and the lesser the density.

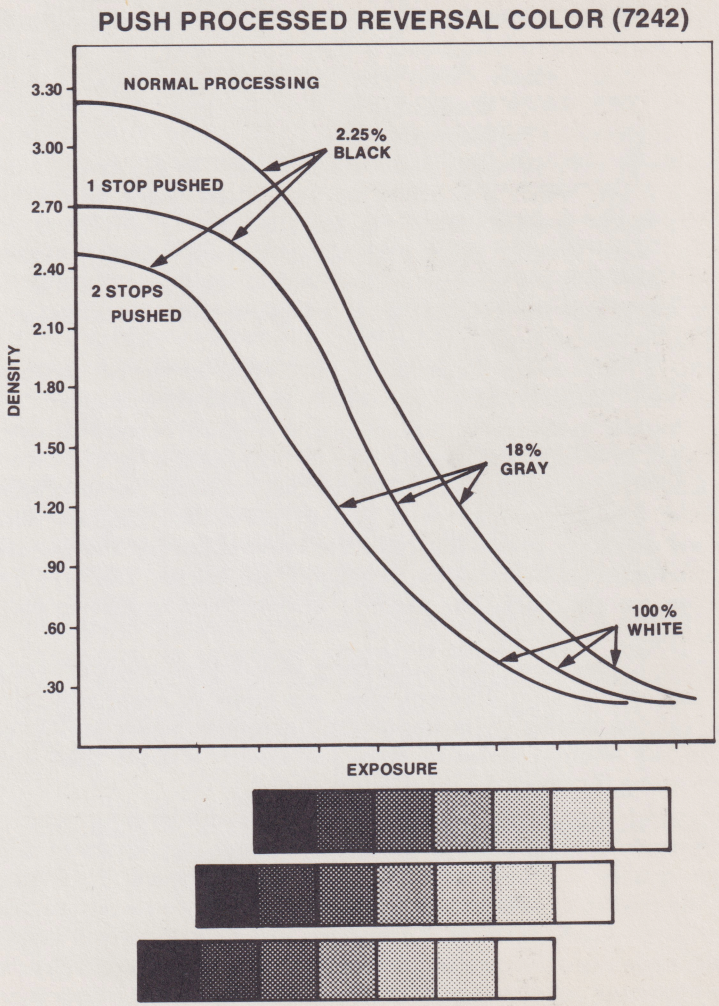
When reversal color film is pushed the contrast in the toe portion (highlights) of the H and D curve increases; the straight line portion (middle tones) remain the same; contrast in the shoulder portion (shadows) may not change but density is decreased.

Eastman Ektachrome Commercial Film (7252) which has a tungsten Exposure Index of ASA 25 (15 DIN), may be underexposed one stop for an effective E.I. of ASA 50 (18 DIN) and push processed one stop. This will produce no increase in gamma and some loss of maximum density. The film will have less exposure latitude when exposed at the higher rating. Image quality will be acceptable under photographic lighting conditions which require the higher film speed. However, the best compromise is to




**Push processing Ektachrome Commercial will cause some loss of maximum density.**

underexpose the film *only one-half stop* and push it one stop in processing. This will produce a less grainy image with good color balance. More than one stop pushing is not advised because the maximum density is reduced excessively so that the shadows print gray or open. The *balance* of the three color layers is upset resulting in highlights shifting toward one color and shadows shifting toward another. Pushing too much will increase grain and the overall image quality will decrease.



Eastman Ektachrome MS Film (5256 and 7256) which has a daylight Exposure Index of ASA 64 (19 DIN) may be pushed one stop with little loss in image quality, and up to three stops (ASA 500, 28 DIN) whenever theatrical or television quality release prints are not required. This would permit exterior daylight instrumentation filming at high camera frame rates.

Eastman Ektachrome EF Films (5241 and 7241 Daylight, and 5242 and 7242 Tungsten may be push processed one stop with no loss in quality, two stops with a little loss, and three or four stops for instrumentation cinematography, or whenever release print quality is not required. The Daylight EF emulsions do not push as well as the Tungsten emulsions. A four stop push on EF Tungsten (5242 or 7242) results in an effective Exposure Index of ASA 2000 (34 DIN), which should cover any low light level situation or ultra-high-speed exposure problem.

The faster reversal color camera films, such as EF, increase in graininess with push processing because such faster emulsions are inherently grainier and also because the grains tend to "clump" with greater push processing, leaving "holes" in the image inbetween the grains. In other words, the color dye image, which duplicates the original silver image, tends to "pull apart" and lose its overall smooth color.

Pushing out-of-light-balance scenes such as night football games with Tungsten EF may produce the following picture: no loss in middle tones — the players look very good, burned up stadium lights whenever the camera pans to include the light sources, and what should appear as black shadows, such as the unlighted distance, appears instead as a grayish mass. The original film, and any duplicate prints, may give the impression that the picture was overexposed because the highlights are burned out and the shadows are not black. The players, however, will appear correctly exposed.

Although one stop push processing will deliver approximately the same results with different labs, two stops or more will produce varying results. It is important, therefore, when switching labs to run another series of tests, particularly if more than one stop pushing is required.

Extended processing reaches a point of diminishing returns where nothing additional is gained by longer development and image quality is needlessly sacrificed. Tests should be filmed with the particular color emulsion to be used in production to discover how much pushing is required and how it affects image quality. Push processing, like everything else in photography, is a compromise, what is gained in one direction is lost in another. If the original reversal film or color negative film is to be duped or used to make an internegative to be used for final release print-

ing, it is wise to carry the testing through *all of the lab procedures* to the final print before making a decision on how much to push process.

Many cinematographers consider push processing as an emergency procedure to be used only when insufficient light is available for a normal exposure, or when a high camera frame rate is required, or when a zoom or telephoto lens of moderate aperture must be used and the scene would be underexposed at the film's normal Exposure Index.

Newsreel, documentary and cinema-verité cameramen filming with available existing light under all kinds of low level light conditions employ push processing as a matter of course. Theatrical directors of photography use push processing for filming night-for-night shots with existing light. However, there is a decided pictorial effectiveness that may be gained by pushing color negative, or color reversal film, one stop in order to increase graininess. A period film or a pseudo-documentary film may be given additional visual interest with increased graininess. Flashbacks, scenes that are supposedly from old newsreels, or reenactments of historical events would benefit from such handling.

If softer contrast is desirable for pictorial reasons, with open grayish shadows, rather than black shadows, an effect similar to *flashing* may be obtained by pushing the film. Pushing flattens contrast because highlight density in the print remains the same but shadow density is less.

Push processing may also be used under normal set lighting conditions whenever a shot or two would require re-lighting and loss of valuable production time. This occurs whenever a smaller lens aperture is required for greater depth of field for a "split-focus" scene, or the camera is operated at a higher than normal 24 fr/sec rate for a slow-motion effect.

Film requiring push processing *must* be shot on a separate roll or magazine, or otherwise separated from normal scenes. Place all such film in separate cans clearly labeled with instructions to the lab. Indicate on the Camera Report, taped to the can, how many stops to push process and also write it in red on the can label!

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## WORKBOOK TAB INDEX

Variously colored plastic tabs, with gummed skirt, may be moistened and attached to Workbook tables, or other often used data pages, to make them easy to locate. Ask for "AICO Handy-Pak Ready Cut Index Tabs" (No. 486) at any stationery store.

## FLASHING COLOR FILMS

Flashing consists of subjecting color film to a weak neutral light, either before or after exposure, for a predetermined length of time and intensity prior to development. Flashing produces a slight "fogging" or "graying-out" of the image that *reduces overall contrast.* Negative flashing affects the *toe* — which in turn affects the *shadows of the print.* Reversal flashing affects the *shoulder* — which affects the *shadows of the reversal original,* or the *print* made from a flashed reversal original. Note that flashing affects *only the shadows* of the print — they are "opened up" and *appear* as if they received more exposure. If the film were *not* flashed the shadows would appear underexposed or dead black. This leads many cameramen to believe that the *speed* of the film is *increased* by flashing. This is not so!

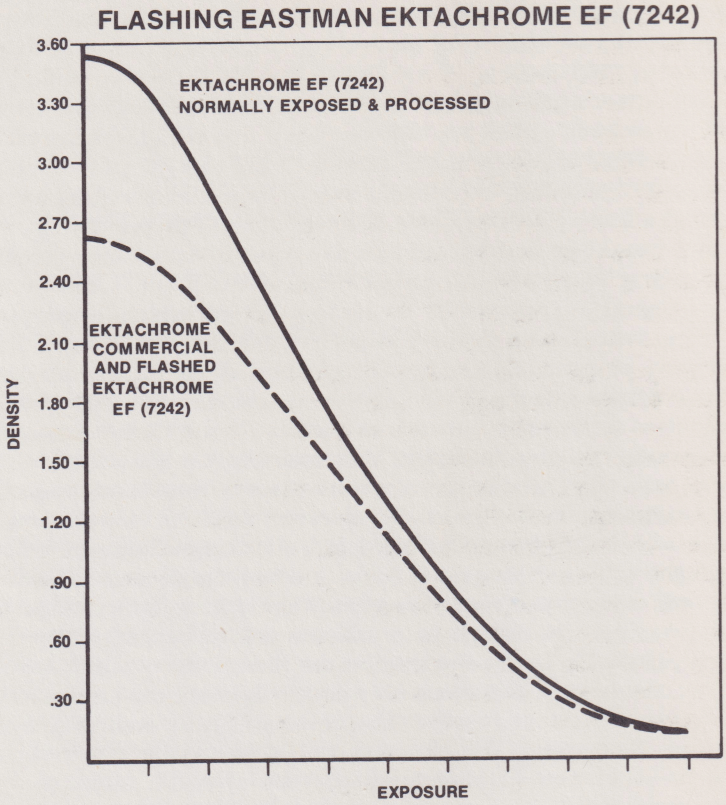
Flashing negative simply *adds density* to the toe, or shadows, so they are heavier and they print lighter. Flashing reversal *subtracts density* from the shoulder, or shadows, so they appear lighter. Flashing can be compared to push processing — which also adds density to negative shadows and subtracts density from reversal shadows. The only difference is that when the film is *flashed it is light fogged* — and when it is *pushed it is chemically fogged!* Both techniques accomplish approximately the same thing in different ways. The only difference is that flashing does not affect the grain structure of the film.

Flashing separates tonal values in the shadows, which would be lost in blackness if the film were not flashed. Lightening the shadows makes them appear on the screen as if they received more light or were given greater exposure. Remember, however, that flashing *decreases contrast,* so it should *not* be used when deep rich blacks are desired, such as in low key scenes or night scenes where higher contrast is required.

Flashing is a standard lab technique for *reducing contrast of high-speed reversal color films,* such as Ektachrome EF, so that it may be inter-cut with Ektachrome Commercial (ECO). The film is run through a printer and generally given a neutral exposure which will, after processing, reduce the maximum density by approximately 1.0. The flashed original EF looks pale and masked with a slight veil, if projected. When the film is printed, however, its contrast increases slightly and cancels out the fog and the resultant image looks very similar to a print from ECO.

Ektachrome Commercial should *not* be pushed more than one stop. If greater speed is required because of low light levels, it is better to shoot with EF and have the lab flash the film — rather than push ECO two stops. This will produce compatible images that will inter-cut with ECO without jarring changes in contrast or shifts in color values.

Flashing Ektachrome EF lowers its maximum density and softens the color, so that it is less saturated (more pastel). A print from flashed EF will closely resemble a print from ECO, except that its grain is noticeably greater. The lowered contrast, however, together with a full exposure tends to reduce the *apparent* size of the grains, so that little difference is noted at normal viewing distances.




**Note that Ektachrome Commercial and flashed Ektachrome EF (7242) have curves that are practically superimposed. This demonstrates why flashed EF will produce a print that closely resembles a print from normally processed ECO. This also shows why normally exposed and normally processed EF may be used as a direct-projection film — and flashed EF may be used as a system-film for making duplicate prints.**

Normal flesh tones on flashed EF will appear similar to ECO. Persons with ruddy faces, however, will tend to grow ruddier. Their faces should be dusted with a neutral theatrical powder, even if make-up is not used. This requires only a few seconds and will simplify color correction later in printing.

Flashing EF is a useful technique for scenes that would benefit from filming with a low light level. Such situations occur when an instrument panel with low intensity color indicator lights must be filmed. Lighting the panel for the slower speed ECO would wash out the panel lights. Shooting with EF with a much lower light level will permit balancing the set lights with the indicator lights so that they will show up.

Color film manufacturers and processing lab personnel agree that it makes no difference whether color film is flashed *before or after* principle exposure in the camera. If the original camera color film is flashed *before exposure* it should be used right away or the desired effect may deteriorate in a few days. Only the footage required should be flashed within a day or so of actual use — a difficult thing to accomplish on location, unless a lab is nearby, or the cameraman improvises a flashing set-up which employs a camera, instead of a printer, to accomplish the task. Since flashing must be precisely controlled it is best done by a processing lab. And, since there is no difference whether the film is pre-flashed or post-flashed, it may as well be flashed *after exposure.*

Film may also be flashed in the camera *while the scene is being filmed.* This may be accomplished in any number of ways by employing a pellicle, a partially silvered mirror, or even a simple piece of optical glass, positioned at a 45 degree angle to reflect the light source *through the lens* — while the picture is photographed through the mirror or glass. The flashing light may be filtered or varied in voltage to produce a *colored effect,* which will show principally in the shadows of the final print — which would be normally black. The shadows will thus take on the color of the light source because in effect the flashing light is adding *colored density.* Remember that flashing only affects the shadows so middle tones and highlights will not be affected, although the scene will be given an overall colored effect. Theoretically, it would be possible, and far simpler, to flash the film with a tiny flashlight-type bulb placed within the camera, away from the intermittent movement. The film could be flashed where it leaves the magazine and enters the camera. Flashing in the camera, rather than through the lens, would not be affected by the lens aperture — so it could be constant for a particular effect, regardless of the T-Stop used to shoot the scene.

Flashing original film in the camera can be dangerous because results are not always *precisely* predictable. This is particularly

true if colored light is employed. The footage once flashed can never be printed normal. A normal print may be required years later for television transmission. Also, the color and intensity of the flashing may be found undesirable later when the picture is edited. Color continuity can affect this, such as when a bluish moonlight sequence is followed by a yellowish warm desert sequence. The individual sequences may be perfectly acceptable but editing may cause a color clash, particularly if inter-cut on a back-and-forth basis.

Another problem also arises: color film varies slightly from batch to batch. A series of tests would have to be run *each time* a new batch of film is used, if results are to be consistent and based on past experience. A large batch of a single emulsion number is generally acquired for a feature picture, so this is no problem. But, the next picture will require new testing with a new batch of color film. An odd roll of film cannot be color flashed in the camera now and then with any degree of control for this reason.

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## RECIPROCITY LAW

Photographic exposure is determined by the *intensity of the light* and the *time* it is allowed to act on the sensitive emulsion. According to the reciprocity law of photochemistry, so long as the exposure remains constant, the response of the emulsion is the same. Increase of light intensity can, therefore, be compensated by *reciprocally proportionate* changes of time and vice versa. The reciprocity law fails, however, when exposure times are extremely short or extremely long. Multilayer color films require the balancing of three different emulsions so that their reciprocity law failure characteristics, over an extended range of exposure times, are similar. Most color films may be exposed over a range of 1/10 to 1/1000 second with similar exposure results.

Ektachrome Commercial film requires 1/3 stop more exposure and a Kodak CC10Y filter for exposures between 1/1000 and 1/10,000 second; and 1/2 stop more exposure (no filter) between 1/2 and 1 second. Ektachrome EF (Tungsten and Daylight) films have extraordinary reciprocity characteristics — no exposure or filter compensation is required for exposure times ranging from 1/10 to 1/100,000 second! Thus ultra-high-speed instrumentation filming does not require adjustment.

Most cameramen need not be concerned with failure of the reciprocity law unless filming animation, titles, models or similar single-frame set-ups that employ animation or stop-motion motors that expose the film longer than 1/2 second.

## LOGARITHMS

A logarithm (log) is an exponent. An exponent is a number (power) which denotes the number of times the base number is multiplied by itself. The base number can be any number other than one. *Common* logarithms are based on 10 because of the decimal system. Thus $10^2$ is $10 \times 10 = 100$. $10^3$ is $10 \times 10 \times 10 = 1000$. Logs are used in photography in connection with exposure and density. Each time exposure or density is doubled it is multiplied by 2. The log of 2 is .3. Therefore, each doubling of exposure produces a .30 density. So, 1 stop difference is .30, 2 stops is .60, 3 stops is .90, etc. Logs simplify photographic computations because they may be added. Thus .30 and .30 are .60, or 2 stops difference. The use of logarithms permits DIN exposure indexes and sound decibels to express very high values with simple numbers. For example, the ASA exposure indexes based on a geometrical progression, require the number 6400 to denote the same film speed as 39 DIN.

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## 16mm and 35mm TEST FILMS

The SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS can supply 16mm and 35mm Test Films for checking picture and/or sound quality. These films are useful in the design of new equipment; for lining up the film pickup system in television stations; as an aid in adjustment of projector and sound reproducer; for "in service" maintenance to indicate causes when projector or sound system is not operating properly. Other films are useful for making adjustments to indicate when performance is within specifications. Release print quality test films with picture and sound are available for individual or comparative demonstrations of projectors. Test films provide a simple equipment performance check without the use of expensive complicated test equipment.

For free lists of test films write:

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## COLOR CONTRAST

Color film introduces an additional dimension to motion pictures: *color contrast* — the *difference in color values* of various significant areas in the scene. Color film accomplishes a great part of subject delineation with color contrast, which must be secured through *tonal contrast* alone in black and white photography. The apparent contrast of a scene photographed in color may be vastly different from that of a black and white scene. This may be easily proved by shooting the same scene, particularly one with very flat contrast or short luminance range, in both black and white and color, or by printing a color scene in black and white and comparing the two. Modeling and image separation requires lighting contrast in black and white filming in order to produce three-dimensional rounded effects and to prevent merging of subject and background.

Color film possesses inherent dimensional qualities because the various colors, even in a flat front lighted scene, tend to model facial features and separate subject matter and background. This effect is even apparent with pastel colors, but it is strongest with brilliant saturated colors. This is the reason that producing acceptable results in color even in poor light or under very flat contrast conditions is much easier than in black and white. Color is realistic because it is representational, while black and white is abstract and can only *suggest* reality. Thus color, even under the poorest light and contrast conditions resembles the real thing and is acceptable by the viewer.

Color provides the viewer with additional information not available in black and white. The different color uniforms provide instant identity in a football analysis film. No time is lost in judging a scene in color because everything is instantly recognized by its color. The seasons, climate, weather, locations, have distinctive colors or colored appearance based on their particular color quality. A brownish autumn scene is easily distinguished from a greenish spring scene. The arctic, tropics, desert or mountainous areas of the world possess a distinctive cool, warm or colored appearance that is particularly characteristic of their respective region. The manner in which a scene is reproduced in color aids in making a *visual statement* that needs no title, narration, dialogue or other crutch to tell the story.

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